AMERICAN SOCIETY
FOR
TESTING MATERIALS

ORGANIZED IN 1898
INCORPORATED IN 1902

PROCEEDINGS
OF THE
TWENTY-SIXTH ANNUAL MEETING
Held at Atlantic City, New Jersey
June 26-29, 1923

VOLUME 23

PART I. COMMITTEE REPORTS
NEW AND REVISED TENTATIVE STANDARDS

PUBLISHED BY
AMERICAN SOCIETY FOR TESTING MATERIALS
1315 Spruce Street, Philadelphia, Pa.
1923

Entered according to Act of Congress by the
AMERICAN SOCIETY FOR TESTING MATERIALS,
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Printed in Philadelphia, U. S. A.

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SUMMARY OF THE PROCEEDINGS OF THE TWENTY-SIXTH ANNUAL MEETING

ATLANTIC CITY, N. J., JUNE 25–29, 1923

THE TWENTY-SIXTH ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at the Chalfonte-Haddon Hall, Atlantic City, N. J., June 25–29, 1923. The following is an analysis of the attendance at the meeting: Members in attendance or represented, 704; guests, 154; total, 858; ladies, 193. The corresponding statistics for the Twenty-fifth Annual Meeting are: Members in attendance or represented, 626; guests, 116; total, 742; ladies, 172.

FIRST SESSION—MONDAY, JUNE 25, 8 P. M.

On Non-Ferrous Metals and Alloys

President George K. Burgess in the chair.

The minutes of the Twenty-fifth Annual Meeting were approved as printed.

The President appointed A. G. Blakeley and R. E. Hess as tellers to canvass the vote for officers.

The report of Committee B-1 on Copper Wire was presented by the chairman, J. A. Capp. Proposed revisions of the Standard Specifications for Hard-Drawn Copper Wire (B 1 – 15), consisting of the deletion therefrom of requirements covering exclusively trolley wire, announced in the report a year ago, were referred to letter ballot of the Society. The proposed Tentative Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire, prepared in cooperation with the American Electric Railway Engineering Association, which are designed to replace the requirements for trolley wire deleted from the above mentioned Specifications for Hard-Drawn Copper Wire, were accepted for publication as a tentative standard.

The proposed Tentative Specifications for Soft Rectangular Copper Wire, and for Hot-Rolled Copper Rods for Wire Drawing were accepted for publication as tentative standards.

The report of the committee was on motion adopted.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by the chairman, William Campbell. The following actions were taken on the recommendations of the committee:

The Tentative Specifications for Copper Pipe, Standard Sizes (B 42 - 22 T) and for Brass Pipe, Standard Sizes (B 43 - 22 T), and the Tentative Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 - 22 T), of Bronze Bearing Metals (B 46 - 22 T) and of Nickel (B 41 - 21 T) were referred to letter ballot for adoption as standard. In recommending that the Tentative Specifications for Pig Lead (B 29 - 22 T) be referred to letter ballot for adoption as standard, the committee asked that the following changes be made:

Section 1.—Change from its present form: namely,

> "Virgin Lead is lead made from ore or similar raw material by direct processes of reduction and refining, and not produced from reworked metal, and is termed Pig Lead."

to read as follows:

> "These specifications are intended to cover lead in pig form, made from ore or similar raw materials, by processes of reduction and refining, and not produced from reworked material."

Section 2.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "Under these specifications [Virgin Lead] *pig lead* is considered in three groups as follows:
>
> I. Corroding Lead
> II. Chemical Lead
> III. Common Lead."

It was explained that these changes were being made to meet the views of Committee E-8 on Nomenclature and Definitions as to form and arrangement. With these revisions, the specifications were referred to letter ballot for adoption as standard.

The proposed revised Tentative Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 - 23 T) submitted by the committee were accepted for publication as tentative, as a substitute for the present tentative specifications of that title.

The revisions in the Standard Methods of Chemical Analysis of Pig Lead (B 35 - 20) were accepted for publication as tentative.

The Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 21 T), with revisions recommended in the report of the committee, were continued as tentative.

A paper by Lawrence Addicks entitled "A Review of the Tin

Situation" was read by W. H. Bassett, and on motion accepted as a part of the report of the committee. Mr. Bassett stated that it was hoped to secure a paper reviewing the Antimony situation for publication with the report in the Proceedings.

On motion, the report, as amended, was adopted.

A paper on "Methods of Casting Test Specimens of Gun Metal," by E. H. Dix, Jr., was presented by the author and discussed.

A paper on "The Influence of the Ratio of Length to Diameter in the Compression Testing of Babbitt Metals," by John R. Freeman, Jr., and Paul F. Brandt was presented by Mr. Freeman.

The report of Committee D-14 on Screen Wire Cloth was presented by the chairman, R. W. Woodward. The committee proposed certain revisions in its report and the proposed tentative specifications appended thereto, consisting in changing the title of the specifications from "Specifications for Non-Ferrous Screen Wire Cloth" to "Specifications for Non-Ferrous Insect Screen Cloth," making the same change throughout the text of the report and specifications; and in omitting from the specifications, Section 2 (*b*), the words "known as 'commercial bronze'" and substituting for the words "zinc copper alloy" in that section, the words "90 per cent copper - 10 per cent zinc alloy." The specifications as thus revised were accepted for publication as a tentative standard, and on motion the report, as amended, was adopted.

The report of Committee E-4 on Metallography was presented by its chairman, W. H. Bassett. The proposed Tentative Recommended Practice for Photography as Applied to Metallography and the proposed Tentative Methods of Metallographic Testing of Non-Ferrous Metals and Alloys were accepted for publication as tentative standards.

The revisions in the Tentative Methods of Metallographic Testing of Iron and Steel (E 3 – 21 T), as recommended in the report of the committee, were accepted and the methods as thus revised continued as tentative.

The proposed revised Tentative Definitions of Terms Relating to Metallography (E 2 – 23 T), submitted by the committee, were accepted for publication as tentative, as a substitute for the present tentative definitions of that title.

A paper on "Identification of Non-Metallic Inclusions in Iron and Steel," by William Campbell and G. F. Comstock, referred to in the report, was then presented by Mr. Campbell and accepted for publication as a part of the report.

On motion, the report of the committee was then adopted.

The tellers on the vote for election of officers presented their report, stating that 827 legal ballots had been cast; and in accordance therewith the President announced the election of the following officers:

For President, to serve for one year: Guilliaem Aertsen.

For Vice-President, to serve for two years: W. H. Fulweiler.

For Members of Executive Committee, to serve for two years: J. H. Chubb, T. G. Delbridge, H. L. Scott, P. H. Walker.

The President requested Past-Presidents G. H. Clamer and J. A. Capp to escort the President-elect to the chair. Mr. Aertsen expressed his appreciation of the honor conferred upon him by his election to the Presidency of the Society and pledged his best endeavors to uphold the ideals of the Society and discharge the obligations of his office.

The Vice-President-elect, W. H. Fulweiler, was then presented to the meeting.

The meeting then adjourned till the following morning.

SECOND SESSION—TUESDAY, JUNE 26, 9.30 A. M.

On Corrosion, Fatigue of Metals and Magnetic Analysis

D. M. Buck in the chair.

The report of Committee A-5 on Corrosion of Iron and Steel was, in the absence of the chairman, J. H. Gibboney, presented by the vice-chairman, H. E. Smith. After referring to the report of Sub-Committee III on Inspection of the Fort Sheridan, Pittsburgh and Annapolis Tests, Mr. Smith called on W. A. Cooper to present the report of Sub-Committee V on Total Immersion Tests and J. A. Aupperle the report of the Special Sub-Committee on Methods for Determining Weight of Coating on Iron and Steel.

Mr. Smith then moved that the proposed Tentative Methods of Determining Weight of Coating on Zinc-Coated Articles and the proposed Tentative Methods of Determining Weight of Coating on Tin, Terne, and Lead-Coated Sheets be accepted for publication as tentative standards. After a discussion of these methods, in which the desirability of weighing samples of sheets individually instead of together was pointed out, F. G. Breyer moved that in the Tentative Methods of Determining Weight of Coating on Zinc-Coated Articles, the reference to weighing sheets together be modified so that the sheets are weighed individually. This amendment was adopted, and both methods were accepted for publication as tentative standards.

On motion, the report of the committee, as amended, was adopted.

The report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys was presented by its chairman, E. C. Lathrop, and, on motion, adopted.

The report of Committee A-8 on Magnetic Analysis was presented by its chairman, F. P. Fahy, and, on motion, adopted.

A paper on "A New Method of Magnetic Inspection," by A. V. de Forest, was presented by the author and discussed.

The report of Committee A-6 on Magnetic Properties was presented by the chairman, C. W. Burrows. The proposed Tentative Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 23 T) were accepted for publication as a tentative standard, to supersede when adopted as standard the present standard methods of the same title.

A paper by R. R. Moore entitled "Resistance of Manganese Bronze, Duralumin, and Electron Metal to Alternating Stresses" was presented by the author and discussed.

A paper entitled "Endurance Properties of Steel: Their Relation to Other Physical Properties and to Chemical Composition," by D. J. McAdam, Jr., was presented by the author and discussed.

The meeting then adjourned till 3 P. M.

THIRD SESSION—TUESDAY, JUNE 26, 3 P. M.

On Wrought and Cast Iron, Coal and Coke and Heat Treatment

Past-President G. H. Clamer in the chair.

A progress report of Committee A-2 on Wrought-Iron was presented by the chairman, H. E. Smith, and was on motion adopted.

Richard Moldenke, Chairman of Committee A-3 on Cast Iron, presented a progress report for the committee, which was discussed. On motion the report of the committee was adopted.

A Topical Discussion entitled "Is It Desirable to Include Chemical Requirements in Specifications for Cast Iron" was introduced by Robert Job, who presented the introductory arguments for the affirmative side of the question, and Richard Moldenke, who presented the introductory arguments for the negative side. Discussion was then participated in by a number of members.

The report of Committee D-5 on Coal and Coke was, in the absence of the chairman, A. C. Fieldner, presented by the secretary, W. A. Selvig. The Tentative Method of Test for Fusibility of Coal Ash (D 22 – 22 T) and the Tentative Method of Shatter Test for Coke (D 141 – 22 T), with revisions recommended in the report of the committee, were referred to letter ballot of the Society for adoption as standard.

The proposed Tentative Method of Test for Volume of Cell Space of Lump Coke and the proposed Tentative Specifications for Gas and Coking Coals were accepted for publication as tentative standards.

On motion, the report of the committee was adopted.

A paper entitled "The Properties of Metallurgical Coke," by G. St. J. Perrott and A. C. Fieldner, was presented by Mr. Perrott and discussed.

A paper by H. A. Schwartz and W. W. Flagle entitled "The Significance of Tool Temperatures as a Function of the Cutting Resistance of Metals" was presented by Mr. Flagle.

The report of Committee A-4 on Heat Treatment of Iron and Steel was presented by the secretary, J. H. Hall, in the absence of the chairman, H. M. Boylston, and was on motion adopted.

The meeting then adjourned till 8 P. M.

FOURTH SESSION—TUESDAY, JUNE 27, 8 P. M.

Presidential Address

Past-President J. A. Capp in the chair.

The chair introduced President George K. Burgess, who presented the annual Presidential Address entitled "The Trend of Standardization."

Honorary Membership in the Society was then conferred upon Past-President Arthur N. Talbot, Professor of Municipal and Sanitary Engineering, University of Illinois, with an appropriate ceremony, in which Professor Talbot was presented to the President for this honor by Past-President George S. Webster.

A popular talk with lantern slides, entitled "Alice in Modernland," was then presented by William A. Durgin, Chief of the Division of Simplified Practice, U. S. Department of Commerce. Mr. Durgin illustrated prevalent absurdities in over-diversification, such as women's shoes, axes and milk bottles, contrasted with the advances certain outstanding industrial leaders have made toward sane standardization. Particular emphasis was placed on Secretary Hoover's vision of the tremendous national importance of simplification and standardization and on the service of the United States Department of Commerce available to any industrial group which wishes to cooperate in undertakings along these lines for individual and national advantage.

The meeting then adjourned till the following morning, and was followed by an informal dance and smoker.

FIFTH SESSION—WEDNESDAY, JUNE 27, 9.30 A. M.

On Steel and Methods of Testing
Reports of Administrative Committees

Vice-President Guilliaem Aertsen in the chair.

The Secretary-Treasurer presented the annual report of the Executive Committee discussing membership activities, work of the standing committees, publications, finances, and administrative matters relating to committee activities and relations with other societies. Special attention was directed to the decision of the Executive Committee not to embark at this time on the policy of holding two meetings annually; also the recommendation that for the present the Society shall not adopt a plan of rotating annual meetings as a fixed policy but continue the policy now defined in the By-laws by which the Executive Committee determines the time and place of meeting.

On motion, the report of the Executive Committee was adopted.

The President then discussed "The Relation of the Society to Research in Engineering Materials," referring briefly to the discussion of the subject in the report of the Executive Committee, and outlining some of the problems in this field that have been receiving consideration. This subject was discussed by Messrs. A. N. Talbot, W. K. Hatt, W. M. Corse and F. E. Schmitt.

The report of Committee E-6 on Papers and Publications was presented by its chairman, C. L. Warwick, and adopted.

The report of Committee A-1 on Steel was presented by its chairman, F. M. Waring. Revisions in the following standards were accepted for publication as tentative:

Standard Specifications for:
- Open-Hearth Steel Girder and High Tee Rails (A 2 – 21)
- Structural Nickel Steel (A 8 – 21)
- Structural Steel for Locomotives (A 10 – 21)
- Structural Steel for Cars (A 11 – 21)
- Boiler and Firebox Steel for Locomotives (A 30 – 21)
- Boiler Rivet Steel (A 31 – 21)

The committee recommended in its report that the proposed Tentative Specifications for Steel Castings appended thereto be accepted for publication as tentative to supersede when adopted as standard the present Standard Specifications for Steel Castings (A 27 – 21). Mr. Waring advised that at a meeting of the committee held Monday afternoon it was voted to change Section 3 (*c*) of the specifications from:

> "Heat treatment shall consist of annealing or normalizing."

to:

> "Heat treatment shall be in accordance with the Tentative Recommended Practice for Heat Treatment of Carbon-Steel Castings (Serial Designation: A 36 - 22 T) of the American Society for Testing Materials, unless otherwise specified by the purchaser."

On motion, this revision was approved and the specifications as thus amended accepted for publication as a tentative standard.

In connection with the proposed revision of the Standard Specifications for Welded and Seamless Steel Pipe (A 53 - 21), Mr. Waring explained that a typographical error existed in that the proposed revision of the phosphorus content from 0.05 to 0.06 is intended to apply to lap-welded pipe and not to welded pipe as printed. This correction was noted and the revision as thus corrected was accepted for publication as tentative.

The revisions in the Tentative Specifications for Boiler and Firebox Steel for Stationary Service (A 70 - 21 T) as recommended in the report of the committee, were accepted and the specifications as thus revised continued as tentative. The proposed revised Tentative Specifications for Steel Plates of Structural Quality for Forge Welding (A 78 - 23 T) submitted by the committee were accepted for publication as tentative, as a substitute for the present Tentative Specifications for Steel Plates for Forge Welding (A 78 - 21 T).

The proposed Tentative Specifications for Steel Plates of Flange Quality for Forge Welding were accepted for publication as tentative standard.

The report of Sub-Committee XII on Ladle Test Ingot Investigation was then presented by J. R. Cain, after which the report of the committee on motion was adopted.

A paper by Louis Jordan on "Gases in Metals" was presented by the author and discussed.

George K. Burgess, chairman of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel, reported briefly on the activities of the committee during the year and then called on N. Richardson, who presented for the committee a preliminary report of an investigation of the effect of sulfur upon three heats of basic open-hearth steel, typifying plate, forging and rail steels, in which sulfur contents of from 0.04 to 0.15 per cent were secured by adding sulfur to the melt during pouring. Tables and charts that accompanied the preliminary report were exhibited.

On motion, the report was accepted for publication in the Proceedings.

The report of Committee E-1 on Methods of Testing was, in the absence of the chairman, J. A. Capp, presented by the secretary of the committee, C. L. Warwick, who called upon the chairman of the Sub-Committee on Revision of Standard Methods of Mechanical Testing of Metallic Materials, H. F. Moore, to present the portion of the report dealing with that subject. There was considerable discussion of the recommendations of the committee respecting the proposed Definitions of Terms Relating to Methods of Testing and the proposed Tentative Methods of Verification of Testing Machines, which were on separate motions of Mr. Moore accepted for publication as tentative standards.

Mr. Moore explained that the proposed Methods of Tension Testing of Metallic Materials attached to the report were offered as a report of progress of the committee in its work of revising these methods as they now appear in the Standard Methods of Mechanical Testing of Metallic Materials (E 1 – 18). On motion, the recommendation of the committee that these suggested methods be accepted for publication as a report of progress was approved.

On motion, the report of the committee was adopted.

A paper entitled "New Developments in Electric Telemeters," by O. S. Peters and R. S. Johnston, was presented by Mr. Johnston and discussed.

A paper by L. B. Tuckerman entitled "Optical Strain Gages and Extensometers" was presented by the author and discussed.

The meeting then adjourned till 8 P. M.

Sixth Session—Wednesday, June 27, 8 P. M.

Symposium on Consistency; The Testing of Glue

W. M. Corse in the chair.

The Chair announced that the first half of the session would be devoted to a Symposium on Consistency. The Symposium was introduced by a paper by F. G. Breyer and Henry Green entitled "A Discussion on Consistency," which was presented by Mr. Green. A Resumé on Consistency, Nomenclature and Methods of Testing, prepared by the Sub-Committee, of Committee E-1, on Consistency, Plasticity and Related Properties, was then presented. A. T. Goldbeck, chairman of the sub-committee, read the introductory paper.

Contributions to the Resumé from the following standing committees were then presented: C-7 on Lime, by W. E. Emley; C-9 on Concrete and Concrete Aggregates, by D. A. Abrams; C-11 on Gypsum, by H. E. Brookby, presented by W. E. Emley; D-2 on Petroleum Products and Lubricants, by R. E. Wilson and F. R. Baxter, presented by Mr. Wilson and Mr. Baxter; D-4 on Road and Paving Materials, presented by A. N. Johnson; D-8 on Waterproofing Materials, by Prévost Hubbard, presented by W. E. Rosengarten. A. W. Dow, a member-at-large of Committee E-1, presented a contribution to the Resumé as a personal member of the sub-committee.

Following the presentation of written discussions by E. C. Bingham and W. H. Herschel, the subject was open for general discussion, which was terminated by agreement at 9.45 P. M. with the understanding that discussions by letter would be received.

The Topical Discussion on The Testing of Glue was introduced by Jerome Alexander, who was followed by F. S. Williams, W. D. Richardson and J. R. Powell, as a committee representing the National Association of Glue and Gelatin Manufacturers at the meeting. A very general discussion was had in which a number of consumers of glue and prominent glue chemists participated. There was a brief discussion of the desirability of organizing in the Society a standing committee on the Testing of Glue.

The meeting then adjourned till the following morning.

SEVENTH SESSION—THURSDAY, JUNE 28, 9.30 A. M.

On Road Materials and Waterproofing

Past-President C. D. Young in the chair.

The report of Committee D-4 on Road and Paving Materials was presented by the chairman, F. P. Smith. On recommendation of the committee, the Tentative Specifications for Broken Slag for Waterbound Base and Wearing Course (D 65 – 20 T), for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base (D 66 – 20 T) and for Block for Durax Granite Pavements (D 132 – 22 T) were referred to letter ballot of the Society for adoption as standard. The Tentative Specifications for Block for Recut Granite Block Pavements (D 131 – 22 T), with the correction noted in the report of the committee, were referred to letter ballot of the Society for adoption as standard.

The revisions in the Standard Method of Test for Softening Point of Bituminous Materials Other Than Tar Products (Ring-and-Ball Method) (D 36 – 21) were approved and the revisions in the Standard

Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements (D 58 – 20) were accepted for publication as tentative.

The recommendation of the committee that the present Tentative Method of Test for Water in Bituminous Materials (D 114 – 21 T) be withdrawn, was approved, subject to favorable action of the Society upon the joint recommendation of Committees D-4 and D-2 that the proposed new Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials be accepted for publication as a tentative standard.

The proposed Tentative Method of Test for the Determination of Bitumen, recommended by the committee, was accepted for publication as tentative to supersede, when adopted as standard, the present Standard Method of Test for Soluble Bitumen (D 4 – 11). The proposed Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride, the proposed Tentative Specifications for Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements and the proposed Tentative Specifications for Asphalt Cement, 30 to 40 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements, with revisions recommended by the committee, were accepted for publication as tentative standards. The proposed Tentative Specifications for Natural or Artificial Sand-Clay Mixtures for Road Surfacing, submitted by the committee, were accepted as a substitute for the present specifications of similar title, bearing the serial designation: D 67 – 20 T.

On recommendation of the committee the following proposed tentative specifications were accepted for publication as tentative standards:

For Broken Slag for Bituminous Macadam Wearing Course
For Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type)
For Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type)
For Sand for Sheet Asphalt and Bituminous Concrete Pavements

Revisions in the Tentative Method of Mechanical Analysis of Subgrade Soils (D 137 – 22 T); the Tentative Method of Float Test for Bituminous Road Materials (D 139 – 22 T); and in the Tentative Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction (D 63 – 20 T), as recommended in the report of the committee, were accepted and the tentative standards as thus revised were continued as tentative.

The revisions in the Tentative Methods of Sampling Bituminous Materials (D 140 – 22 T), as recommended in the report of the committee, were accepted and the methods as thus revised continued as tentative. The revisions in these methods have been jointly recommended by Committees D-4 and D-8 and the revised methods substitute the present Tentative Methods of Sampling Bituminous Materials (D 140 – 22 T) and the Tentative Methods of Sampling Bituminous Materials Shipped in Barrels or Drums (D 148 – 22 T), the latter methods having been withdrawn by Committee D-8.

Revisions of the following tentative specifications are contained in the report of the committee as preprinted:

For Asphalt Cement (D 99 – 22 T), (D 100 – 22 T), (D 101 – 22 T), (D 102 – 22 T), (D 103 – 22 T), (D 133 – 22 T), (D 134 – 22 T), and (D 135 – 22 T);
For High-Carbon Tar for Surface Treatment, Cold Application (D 104 – 21 T);
For Low-Carbon Tar for Surface Treatment, Cold Application (D 105 – 21 T);
For High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 106 – 21 T);
For Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 107 – 21 T);
For High-Carbon Tar for Surface Treatment, Hot Application (D 108 – 21 T);
For Low-Carbon Tar for Surface Treatment, Hot Application (D 109 – 21 T);
For High-Carbon Tar Cement (D 110 – 21 T);
For Low-Carbon Tar Cement (D 111 – 21 T);
For Coal-Tar Pitch for Stone Block Filler (D 112 – 22 T).

On recommendation of the committee, additional minor revisions were made. These revisions were approved and the amended specifications, as revised, were continued as tentative.

The committee submitted a revision, which had been voted on at a meeting of the committee held during the Annual Meeting, of the present Standard Methods of Test for Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials (D 55 – 19) consisting of a change in the graduations on the burette of the Jackson apparatus to enable the apparatus to be used with a wider range of materials. This will also involve slight changes in that portion of the text referring to the apparatus, but no essential change in method or apparatus is involved in the recommendation offered.

This revision of the Standard Methods D 55 - 19, which will appear as an Addendum to the Report of Committee D-4,[1] was accepted for publication as tentative.

On motion, the report of the committee, as amended, with the addendum, was adopted.

W. K. Hatt, Director of the Advisory Board on Highway Research of the National Research Council, gave a very interesting account of the recent International Road Congress held at Seville, Spain, May 6 to 13, in which he discussed recent highway developments in Europe and gave some reflections upon the Congress itself.

A paper by J. W. Kennedy entitled "Some Relations Between the Characteristics of Straight Distilled Tar Residues" was presented in the absence of the author by the Secretary-Treasurer.

A paper entitled "Use of Air Bath in Determination of Solid Residue of Road Oils at 100 Penetration," by H. F. Clemmer and H. C. Helmle, was presented by Mr. Clemmer and discussed.

A paper by Earl B. Smith entitled "Accelerometer for Measuring Impact" was presented by the author and discussed.

The report of Committee D-8 on Waterproofing Materials was presented by the chairman, S. T. Wagner. On the recommendation of the committee, the following proposed tentative specifications were accepted for publication as tentative standards:

For Asphalt Mastic for Use in Waterproofing
For Bituminous Grout for Use in Waterproofing Above Ground Level
For Bituminous Grout for Use in Waterproofing Below Ground Level
For Felted Fabrics Saturated with Bituminous Substances for Use in Waterproofing
For Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing
For Burlap Saturated with Bituminous Substances for Use in Waterproofing

The revisions in the following tentative methods and specifications, as recommended in the report of the committee, were accepted and the specifications as thus revised continued as tentative:

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[1] See p. 410.—ED.

Tentative Methods of:

Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 - 22 T)

Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing (D 146 - 22 T)

Tentative Specifications for:

Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (D 40 - 22 T)

Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level (D 144 - 22 T)

Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 42 - 22 T)

Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 145 - 22 T)

The recommendation of the committee that the present Tentative Methods of Sampling Bituminous Materials Shipped in Barrels or Drums (D 148 - 22 T) be withdrawn, was approved, in view of the favorable action of the Society upon the joint recommendation of Committees D-4 and D-8 that the proposed revised Tentative Methods of Sampling Bituminous Materials be accepted for publication as tentative.

On motion, the report of the committee was adopted.

There was then presented a motion picture entitled "Tests for Better Roads," furnished through the courtesy of the U. S. Bureau of Public Roads, illustrating the investigations of the Bureau at Arlington Farms, Washington, D. C., on subgrades, behavior of road slabs of different design under impact, stability of different kinds of bituminous mixtures, and tests of the wearing quality of portland cement concrete pavements. The last two tests are conducted on two circular tracks which were well illustrated in the picture.

The meeting then adjourned till 3 P. M.

EIGHTH SESSION—THURSDAY, JUNE 28, 3 P. M.

On Timber, Rubber and Textiles

W. H. Fulweiler in the chair.

The report of Committee D-7 on Timber was presented by its chairman, Hermann von Schrenk. The committee recommended the withdrawal from the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 18) of the sub-division designated "Float Test of Residue" comprising Sections 17 and 18 and further recommends that the Tentative Method of Float Test for Bituminous Road Materials (D 139 – 22 T) prepared by Committee D-4 on Road and Paving Materials, with the revisions recommended by that committee in its report for this year, be approved as a method of testing creosote oil. The committee also recommended that Sections 19 and 20 of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 18), comprising a description of a coke residue test, be withdrawn and that the Proposed Tentative Method of Test for Coke Residue of Creosote Oil, appended to its report, be accepted for publication as a tentative standard to supersede, when adopted as standard, the present method described in the Standard Methods D 38 – 18. The recommendations of the committee were approved.

Mr. von Schrenk then referred to the work of the Central Committee on Lumber Standards, with which Committee D-7 is at present cooperating.

On motion, the report of the committee was adopted.

A paper by Cloyd M. Chapman entitled "A Fungus Bed Test of Wood Preservatives" was presented by the author and discussed.

The report of Committee D-11 on Rubber Products was, in the absence of the chairman, F. M. Farmer, presented by the secretary, C. B. Martin. On recommendation of the committee, the Tentative Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not Exceeding 3000 Volts to Ground (D 120 – 22 T); and the Tentative Specifications for Rubber Pump Valves (D 151 – 22 T) were referred to letter ballot of the Society for adoption as standard. The Tentative Specifications for Cotton Rubber-Lined Fire Hose for Private Fire Department Use (D 14 – 22 T) and the Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public Fire Department Use (D 26 – 21 T), with revisions recommended in the report of the committee, were also referred to letter ballot of the Society for adoption as standard.

The following proposed new tentative specifications were accepted for publication as tentative standards: For Wrapped Cold Water Hose, and for Rubber Matting for Use Around Electrical Apparatus or Circuits not Exceeding 3000 Volts to Ground.

The revisions in the Tentative Methods of Testing Rubber Products (D 15 – 22 T) and the Tentative Specifications for Rubber Belting for Power Transmission (D 53 – 21 T), as recommended in the report of the committee, were accepted and the tentative standards as thus revised were continued as tentative.

Mr. Martin explained that the preprint of the report of the committee was in error with respect to the revisions of Table II in the Tentative Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 – 21 T) and asked that the following test pressures be substituted for those in the report:

700	625
675	600
650	575
625	575

With these changes the recommendation of the committee was approved and the specifications as thus revised were continued as tentative.

Two additional revisions in the Tentative Specifications for Braided Air Hose for Use with Pneumatic Tools (D 60 – 21 T), which had inadvertently been omitted in the preprint of the report, were presented on the floor of the meeting, as follows:

Section 9 (d).—Change from its present form: namely,

> "The set, or permanent elongation, following a stretch from 2 in. to 6 in., shall not exceed 25 per cent."

to read as follows:

> "The set, or permanent elongation, following a stretch from 2 in. to 5 in. in the case of the tube and from 2 in. to 7 in. in the case of the cover, shall not exceed 25 per cent in either tube or cover."

Table I.—Change Table I on test pressures to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

TABLE I.—TEST PRESSURES

INSIDE DIAMETER OF HOSE, IN.	TEST PRESSURE, LB. PER SQ. IN.	
$\frac{3}{8}$	[950]	*800*
$\frac{7}{16}$	[925]	*800*
$\frac{1}{2}$	[900]	*800*
$\frac{5}{8}$	[850]	*800*
$\frac{3}{4}$	[750]	*800*
1	700	
$1\frac{1}{8}$	650	
$1\frac{1}{4}$	600	
$1\frac{1}{2}$	550	

The revisions in the specifications were accepted and the specifications as thus revised were continued as tentative.

On motion, the report of the committee was adopted.

A paper entitled "An Apparatus and Method for Determination of Resistance to Abrasion of Rubber Products," by W. W. Evans, was presented by the author and discussed.

The report of Committee D-13 on Textile Materials was presented by its chairman, A. E. Jury.

The proposed Tentative Specifications for Imperfections and Tolerances for Cord Tire Fabrics; for Tolerances and Test Methods for Cotton Yarns and Cords; and for Tolerances for Hose Ducks and Belt Ducks, were accepted for publication as tentative standards.

The proposed revised Tentative Specifications for Imperfections and Tolerances for Square-Woven Tire Fabrics, submitted by the committee as a substitute for the present Tentative Specifications for Imperfections and Tolerances for 60-in. $17\frac{1}{4}$-oz. Square-Woven Builder Fabric (D 122 - 22 T), were accepted for publication as tentative.

The revisions in the Standard General Methods of Testing Cotton Fabrics (D 39 - 20) recommended by the committee were accepted for publication as tentative.

On motion, the report of the committee was adopted.

A paper entitled "A Constant Load Rate Testing Machine for Textiles," was presented by the author, G. B. Haven.

There was then presented a motion picture entitled "From Bale to Cloth," furnished through the courtesy of Saco-Lowell Shops, Boston, Mass., illustrating the processes of manufacturing fabrics from the cotton in its raw state to the finished product.

The meeting then adjourned till 8 P. M.

NINTH SESSION—THURSDAY, JUNE 28, 8 P. M.

On Preservative Coatings

(*Held Simultaneously with the Tenth Session*)

P. H. Walker in the chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented, in the absence of the chairman, Allen Rogers, by G. W. Thompson. On recommendation of the committee, the Tentative Specifications for Perilla Oil (D 125 - 22 T) and the Tentative Methods of Routine Analysis of Pigments (D 126 - 22 T) were referred to letter ballot of the Society for adoption as standard.

The revisions in the Tentative Specifications for Tung Oil (D 12 - 22 T), as recommended in the report of the committee, were accepted and the specifications as thus revised continued as tentative.

The proposed Tentative Method of Test for Specific Gravity of Pigments and the proposed Tentative Methods of Testing Oleo-Resinous Varnishes were accepted for publication as tentative standards. The proposed Tentative Methods of Testing Shellac were accepted for publication as a tentative standard to supersede, when adopted as standard, the present Standard Methods of Testing Shellac (D 29 - 17).

The revisions in the Standard Definitions of Terms Relating to Paint Specifications (D 16 - 22) recommended by the committee were accepted for publication as tentative.

The report of Sub-Committee V on Linseed Oil, of Committee D-1, which had not been included in the report as preprinted, was read by R. L. Hallett, secretary of the committee, and was on motion accepted for publication.

Three papers were read by title by R. E. Hess as appendices to the Report of Sub-Committee IX on Varnish, of Committee D-1:

"Accelerated Elasticity Test for Oleo-Resinous Varnishes (The Kauri Reduction Test)," by L. V. Pulsifer.

"Measurement of the Thickness of Varnish Films," by E. A. Stoppel.

"Physical Properties of Varnish Films Indicated by Stress-Strain Measurements," by H. A. Nelson.

On motion, the report of the committee was adopted.

The following papers were then presented by their authors and discussed:

"Further Studies of the Physical Properties of Drying-Oil, Paint and Varnish Films," by H. A. Nelson and G. W. Rundle, presented by Mr. Nelson.

"Some Optical Properties of White Paint Pigments in the Ultra-Violet Spectrum," by A. H. Pfund.

"The Effect of Certain Paint Films on Ultra-Violet Light," by R. L. Hallett.

"Color," by G. W. Thompson.

"A New Combined Viscometer and Plastometer," by E. C. Bingham and H. A. Murray, Jr., presented by Mr. Bingham.

The meeting then adjourned till the following morning.

TENTH SESSION—THURSDAY, JUNE 28, 8 P. M.

On Cement, Lime, Gypsum and Ceramics. Nomenclature

(*Held simultaneously with the Ninth Session*)

E. D. Boyer in the chair.

The report of Committee C-4 on Clay and Cement Sewer Pipe was presented by A. J. Provost, Jr., vice-chairman of the committee.

On recommendation of the committee the revisions in the Standard Specifications for Clay Sewer Pipe (C 13 - 20) and in the Standard Specifications for Cement-Concrete Sewer Pipe (C 14 - 20) recommended by the committee were accepted for publication as tentative.

Mr. Provost stated that the following resolution on the death of their chairman, Dr. Rudolph Hering, had been adopted by the committee:

RUDOLPH HERING

1847-1923

Committee C-4 of the American Society for Testing Materials desires to express its profound sorrow for the death of its honored Chairman, Rudolph Hering.

In 1904, Dr. Hering became a member of the American Society for Testing Materials—the year in which the then Committee L, now Committee C-4, was being organized, with Charles F. McKenna as Chairman *pro tempore.* Upon the committee's formation in the following year, Dr. Hering became its first chairman and for the eighteen years during which the Committee has functioned he has faithfully served as its head.

Committee C-4 has been fortunate in having the benefit of the advice and guidance of a chairman of such wide experience and knowledge in the practice of engineering, gained through a period of well over an half century, during which time he had come into intimate contact with and had been responsible for many of the large engineering works of his time. His wide acquaintance, the notable service rendered to the profession, the kindly feeling for and generous advice and assistance so freely accorded to his associates resulted in a very general feeling that he was the Dean of American sanitary engineers.

Through the death of Dr. Hering the Society has lost not only a member of genuine distinction, but one whose sterling qualities and sympathetic understanding have stimulated and won the affectionate esteem of all who were privileged to know him, and Committee C-4 has lost a chairman whom all respected for his sound judgment, his absolute fairness and his unquestioned impartiality.

On motion of Mr. Provost, the report of the committee including the resolution was adopted.

The report of Committee C-3 on Brick was presented by its chairman, T. R. Lawson. On recommendation of the committee the Tentative Specifications for Clay Sewer Brick (C 32 - 21 T) were referred to letter ballot of the Society for adoption as standard.

On motion, the report of the committee was adopted.

The progress report of Committee C-1 on Cement was presented by its chairman, R. S. Greenman, and adopted.

A paper entitled "Late Data on the Effect of Finer Grinding and a Higher SO_3 Content upon the Physical Properties of Portland Cement" was presented by the author, P. H. Bates.

The report of Committee E-8 on Nomenclature and Definitions was presented by the chairman, Cloyd M. Chapman, and adopted.

The report of Committee C-10 on Hollow Building Tile was presented by S. H. Ingberg, the newly elected chairman. Mr. Ingberg stated that at a meeting of the committee held during the annual meeting it had been decided to withdraw the recommendation contained in the printed report that the revised Tentative Definitions of Terms Relating to Hollow Tile appended thereto be referred to letter ballot for adoption as standard. It was explained that certain suggested revisions had been brought to the attention of the committee since its report was preprinted and it seemed desirable to continue the definitions as tentative for another year while these revisions were being considered. Mr. Ingberg moved for the committee that the definitions be continued as tentative, with certain minor revisions in wording and the omission of the definition of the term "Terra Cotta," retaining the footnote now under the definition, which reads:

> "The term 'terra cotta' should not be used to designate hollow tile."

The Secretary-Treasurer pointed out the importance of retaining in this footnote the use for which the term "terra cotta" is now reserved, and the following wording for the footnote was suggested:

> "The term 'terra cotta,' which is applied to ornamental building units of burned clay, should not be used to designate hollow tile."

With this correction the motion to continue the definitions as tentative was adopted.

On motion, the report of the committee, as amended, was then adopted.

The report of Committee C-6 on Drain Tile was presented by S. H. McCrory in the absence of the chairman, Anson Marston. The revisions in the Standard Specifications for Drain Tile (C 4 – 21) recommended by the committee were accepted for publication as tentative.

On motion, the report of the committee was adopted.

The report of Committee C-11 on Gypsum was presented by the chairman, W. E. Emley. On recommendation of the committee, the proposed Tentative Specifications for Gypsum Partition Tile or Block were accepted for publication as tentative standard.

The revisions in the Tentative Specifications for Gypsum (C 22 – 22 T) and in the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 12 T), recommended in the report, were accepted and the tentative standards as thus revised were continued as tentative.

The Tentative Methods of Testing Gypsum and Gypsum Products

(C 26 – 21 T) were referred to letter ballot of the Society for adoption as standard with the revisions recommended in the report of the committee.

The revision recommended in the Standard Specifications for Calcined Gypsum (C 23 – 22), consisting of the omission of a footnote, was accepted for publication as tentative.

At the suggestion of Mr. Emley, the paper appended to the report on "The Fire Resistive Properties of Gypsum" was presented by its author, S. H. Ingberg. Mr. Emley then presented in abstract the paper appended to the report on "Volumetric Changes of Gypsum," by J. Miller Porter. The paper appended to the report, entitled "Microscopic Examination of Raw and Calcined Gypsum," by E. S. Larsen, was read by title and accepted for publication.

On motion, the report of the committee was adopted.

The report of Committee C-7 on Lime was presented in the absence of the chairman, H. C. Berry, by the secretary, G. W. Hutchinson.

The revisions in the Tentative Specifications for Hydrated Lime for Structural Purposes (C 6 – 22 T) and in the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (C 50 – 22 T), recommended in the report of the committee, were accepted and the tentative standards continued as tentative.

On motion, the report of the committee was adopted.

W. H. Fulweiler, the newly elected chairman of Committee C-8 on Refractories, presented a report of progress for Committee C-8, which was accepted for publication.

The meeting then adjourned till the following morning.

ELEVENTH SESSION—FRIDAY, JUNE 29, 9.30 A. M.

On Petroleum Products, Thermometers, Electrical Insulating Materials and Slate

(Held simultaneously with the Twelfth Session.)

T. G. Delbridge in the chair.

The report of Committee D-15 on Thermometers was presented by its chairman, W. H. Fulweiler. The proposed Tentative Specifications for A.S.T.M. Partial-Immersion Thermometer, -20 to $+150°$ C., 0 to $+300°$ F.; for A.S.T.M. Partial-Immersion Thermometer, -5 to $+300°$ C., $+20$ to $+580°$ F.; and for A.S.T.M. Partial-Immersion Thermometer, -5 to $+400°$ C., $+20$ to $+760°$ F., with the addition of the words "For General Use" in the title of each specification, were accepted for publication as tentative standards.

Mr. Fulweiler stated that the proposed Tentative Specifications for A.S.T.M. Thermometers for Use with Saybolt Viscosimeter, appended to the report, had been reviewed by Committee D-2 (for which committee they had been prepared) since the report was preprinted, as a result of which certain revisions had been made and Committee D-2 had voted to include the specifications as revised with its Tentative Methods for Determination of Viscosity.

On motion, the report of the committee as amended was adopted.

A paper on "A Method for the Estimation of the Color of Oils," by D. C. Cox, was presented by the author and discussed.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by K. G. Mackenzie, vice-chairman. Proposed Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer; proposed Tentative Method of Test for Steam Emulsion of Lubricating Oils and proposed Tentative Methods of Testing Gas Oils were accepted for publication as tentative standards. The proposed Tentative Method of Test for Color of Lubricating Oils by Means of Union Colorimeter, with revisions proposed at the meeting, were also accepted for publication as a tentative standard.

The revisions in the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (D 86 - 21 T); in the Tentative Method for Flash and Fire Points by Means of Open Cup (D 92 - 21 T) and in the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 - 22 T), as recommended in the report of the committee, were accepted and the methods as thus revised continued as tentative.

The proposed Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials was accepted for publication as a tentative standard, to replace the present Tentative Method of Test for Water in Petroleum Products (D 95 - 21 T). This new method is being recommended jointly by Committees D-2 and D-4 as a result of cooperative work carried out by the Sub-Committee, of Committee E-1, on Water in Bituminous Materials. Committee D-4 has recommended the withdrawal of its Tentative Method of Test for Water in Bituminous Materials (D 114 - 21 T).

Mr. Mackenzie stated that at a meeting held the previous day the committee had voted to combine the Tentative Method of Test for Viscosity of Lubricants and the Tentative Method of Test for Viscosity of Fuel Oils and Other Oils of Similar Viscosity, and to include in the combined method the Tentative Specifications for A.S.T.M. Thermometers for Use with Saybolt Viscosimeter as revised by Committee D-15. On motion, this action of the committee was approved.

On motion, the report of the committee as amended was adopted.

The report of Committee D-9 on Electrical Insulating Materials was presented by H. S. Vassar, secretary, in the absence of the chairman, F. M. Farmer. On recommendation of the committee, the proposed Tentative Method of Test of Electrical Insulating Materials for Voltage Effects at Radio Frequencies and the proposed Tentative Methods of Testing Cable Splicing and Pothead Compounds were accepted for publication as tentative standards.

The revisions in the Tentative Methods of Testing Insulating Varnishes (D 115 - 22 T) and the Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials (D 149 - 22 T), as recommended in the report of the committee, and the additional revisions recommended on the floor of the meeting, were accepted and the methods as thus revised continued as tentative. The revisions in the Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies (D 150 - 22 T), as recommended in the report of the committee, were accepted and the methods as thus revised were continued as tentative.

On motion, the report of the committee as amended was adopted.

The chairman, Mr. Delbridge, stated he was obliged to leave the meeting and called on F. R. Baxter to preside.

A paper on "Electrical Insulating Varnishes," by J. A. Findley, Dean Harvey and S. T. Rodgers, was presented by Mr. Harvey and discussed.

A Topical Discussion on Slate was introduced by the presentation of the following papers:

"The Characteristics of Slate," by Oliver Bowles;
"Electrical Slate," by Dean Harvey and J. J. Keyes, presented by Mr. Harvey;
"Insulation Tests of Slate for Electrical Use," by R. M. Spurck, presented by E. S. Lee.

The subject was then discussed by representatives of the National Slate Association and a general discussion followed.

The meeting then adjourned until 8 P. M.

TWELFTH SESSION—FRIDAY, JUNE 29, 9.30 A. M.

On Concrete

(Held simultaneously with the Eleventh Session)

Past-President George S. Webster in the chair.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by its chairman, A. T. Goldbeck. On motion of E. G. Sutton, the proposed Revised Tentative Specifications for Concrete Aggregates (C 33 – 23 T) were further revised, as follows:

Section 2.—Change the percentage passing No. 4 sieve from 100 per cent to 85 per cent.

Add a requirement of 100 per cent for the percentage passing a $\frac{3}{8}$-in. sieve.

Section 4.—Cross out the words "on less important work."

Section 5.—Add the words "4 or" after the word "Section" in the last line.

Section 9 (a).—Change the percentage for material passing maximum size sieve from 100 to 95.

These revisions were approved and the amended specifications as revised were continued as tentative.

The following paragraph was added to the report of the committee, on motion of Cloyd M. Chapman:

> "The Standard Method of Test for Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials (D 55 – 19) specifies a form of Jackson apparatus with graduations reading to 0.01 specific gravity and has a range which is not sufficient to cover all classes of aggregates which it may be desirable to test. A modified Jackson apparatus having a range of 2.0 to 3.5 specific gravity with graduations reading to 0.01 specific gravity is acceptable for use in this test. Committee C-9 recommends to Committee D-4 on Road and Paving Materials, which committee has jurisdiction over the method in question, that the standard method be modified in this respect."

On motion, the report of the committee, as amended, was adopted.

A progress report from Committee C-2 on Reinforced Concrete was read by R. E. Hess and adopted.

The following papers were presented by their authors and discussed:

"Blast-Furnace Slag as an Aggregate in Concrete," by Raymond Harsch;

"A Penetration Test for the Workability of Concrete Mixtures with Particular Reference to the Effects of Certain Powdered Admixtures," by J. C. Pearson and F. A. Hitchcock, presented by Mr. Pearson;

"An Investigation in the Use of Calcium Chloride as a Curing Agent and Accelerator of Concrete," by H. F. Clemmer and Fred Burggraf, presented by Mr. Clemmer;

"Fatigue of Mortar," by R. B. Crepps.

The motion picture entitled "Tests for Better Roads," which had been presented at the Seventh Session on Thursday morning, was shown again.

The meeting then adjourned till 8 P. M.

THIRTEENTH SESSION—FRIDAY, JUNE 29, 8 P. M.

Symposium: What Properties of and Methods of Making Concrete Require Further Investigation?

Past-President A. N. Talbot in the chair.

In opening the meeting, the Chair stated that the behavior of out-door concrete is to-day a subject of special interest and significance and that its importance has been recognized by Committee C-9 on Concrete and Concrete Aggregates in the study now being given to the conditions affecting the durability of concrete in structures. The Symposium had been arranged to provide opportunity for enlightened discussion and constructive criticism, with the hope that engineers will be aroused to the need of further intensive study of concrete as a material.

The Symposium was introduced by F. C. Wight.

The subject "Quality of Materials" was introduced by two papers: "What Properties of and Methods of Making Cement Require Further Investigation," by P. H. Bates, and "Influence of Aggregates on the Durability of Concrete," by D. A. Abrams, presented by H. F. Gonnerman.

The topic "Methods of Making Concrete" was opened under two headings: A paper on "Proportioning and Mixing" was presented by its author, R. B. Young. W. A. Slater then described, with illustrations, tests under the auspices of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete to determine the practicability of the several recommendations in the tentative specifications of the Joint Committee. These tests are being made in connection with the erection of the Victor Talking Machine Co. building, in Camden, N. J.

A brief statement was presented for the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete by its chairman, Richard L. Humphrey, describing the progress of its work during the past year and stating what the committee plans to do during the coming year. It is expected to begin work in the fall upon the final revision of the tentative specifications submitted two years ago with the Joint Committee's first report.

The topic "Behavior of Concrete Under Service Conditions" was introduced by the following five papers:

"Mass Concrete," by A. P. Davis, which in the absence of the author was presented in abstract by the Secretary-Treasurer.

"Concrete Exposed to Atmospheric Conditions," by P. J. Freeman. Mr. Freeman showed illustrations of deteriorated concrete. In presenting his paper he called attention to the desire of Committee C-9 to receive information regarding the behavior of concrete for the confidential use of the committee in the study of conditions affecting the durability of concrete; and he also urged the importance of keeping adequate records of present-day construction so that they will be available for use in later years when the behavior of present-day construction is under observation.

"Concrete in Roads," by A. T. Goldbeck.

"Concrete Exposed to Sea Water," presented by S. C. Hollister with lantern slides.

"Concrete Exposed to Alkaline Conditions," by G. M. Williams, which in the absence of the author was presented in abstract by the Secretary-Treasurer.

Following these introductory papers, written discussions were presented by their authors unless otherwise noted: H. S. Spackman (presented by Secretary-Treasurer), R. W. Lesley, W. F. Purrington, R. W. Crum, J. T. Campbell, W. E. Hart (with illustrations), R. S. Greenman, J. J. Paine, W. G. Atwood, E. E. Butterfield (with specimens), H. S. Mattimore, J. C. Pearson (presented by title), W. M. Kinney, R. L. Bertin, M. O. Withey (presented by title), Carrol Thompson (presented by title).

The discussion was then open for remarks from the floor and the following participated: B. C. Collier, R. J. Wig, Ernest Ashton.

Under the heading of miscellaneous business the Secretary-Treasurer announced that the Executive Committee had received the following letter of resignation from Vice-President W. H. Walker:

Los Angeles, Calif.,
June 13, 1923.

EXECUTIVE COMMITTEE,
AMERICAN SOCIETY FOR TESTING MATERIALS,
PHILADELPHIA, PA.

Gentlemen:

A year ago when I accepted the nomination for vice-president of the Society, it was my expectation that my business interests would keep me in the East, and that it would be possible for me to attend the meetings of the Executive Committee in Philadelphia. But during the last year I have been for the greater portion of the time west of Chicago, and have not found it possible to be of any real service to the Society.

It is now clear that my business engagements will keep me on the Pacific Coast for the greater part of next year, and possibly indefinitely, and it therefore seems expedient for me to hand in my resignation as a vice-president of the Society at this time, in order that the Committee may appoint a vice-president in my place. I regret the necessity of doing this but I do not wish to be a figurehead on the one hand, nor can the Society afford to have officers who are not actively in touch with its affairs on the other. The advisability of this action is therefore clear.

Wishing the Society continued success, I remain,

Yours very truly,
(Signed) WM. H. WALKER.

The Executive Committee had voted to accept this resignation with sincere regret; and in accordance with the provision of the By-laws it had appointed F. M. Farmer, Chief Engineer, Electrical Testing Laboratories, New York City, a retiring member of the Executive Committee, to fill the unexpired term of the Vice-President.

There being no further business, the Chair declared the Twenty-sixth annual meeting adjourned *sine die.*

AMERICAN SOCIETY FOR TESTING MATERIALS.

ORGANIZED IN 1898.
INCORPORATED IN 1902.

PROCEEDINGS.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

THE TREND OF STANDARDIZATION

ANNUAL ADDRESS BY THE PRESIDENT, GEORGE K. BURGESS

JUNE 26, 1923

Many of the Presidential Addresses presented before this Society have dealt, and very appropriately so, with one or another phase of the subject of Standardization, and this one will be no exception to that practice. Indeed, by virtue of the positions held by your President in the domain of standards, as related to their establishment, the formulation and promulgation of specifications, the development of testing methods and the orientation of research relating to standards in the fields of science, technology and engineering, the specifications for this address would appear to be set forth with considerable clearness; and I welcome the opportunity of discussing with you the present trend and inter-relations of the various aspects of the problems of standardization, particularly as they are bound up with the traditions, practices and policy of our Society.

A year ago, on accepting the Presidency, I ventured to suggest as a program for the year just passed the desirability of making our standards more generally applicable and mentioned three opportunities that lie before us: the adoption of our standards as American Standards by submission to the American Engineering Standards Committee; the extension of the use of our standards for export trade; and the making of our standards available for the use of the Government, which has recently organized a Federal Specifications Board for the purpose of unifying specifications for government purchases.

What have been the year's accomplishments? They are set forth in detail in the report of your Executive Committee and make an impressive exhibit demonstrating the vitality and vigor which are characteristic of this Society. Before, however, taking up some of the specific problems of concern to us of the American Society for Testing Materials, it may be well to outline the background on which we are basing our standardization program.

Perhaps some of us consider the idea of standardization as of recent creation. We certainly all realize that, whether of ancient or modern origin, there now is tremendous and an ever accelerated activity in this field as shown by the recent establishment and thriving condition of new agencies both among the engineering and industrial fraternities and in governmental circles, not only here in the United States but also in many other countries.

Again, some of us may be of the opinion that standardization has been developed first in connection with engineering and industrial practices, and from them spreading to other activities. We are most familiar with and think in terms of our own profession, not consciously realizing, perhaps, that there may be other fields in which certain forms of standardization have been dominant for ages. A study of this question would probably reveal the existence, in many walks of life, of a constant struggle between the ideas of conformity and maintenance of standards on the one hand, and those of diversity in practice and breaking away from accepted customs on the other hand.

Even nature herself manifests most strikingly this antithesis of permanence of species—the standard form—with variation among individuals within certain tolerances of composition, dimensions, habits, and strength, and the tendency to produce diverse forms to meet ever changing conditions of environment resulting eventually in the evolution of new species or the formation of new natural standards. In nature, the establishment of new types or standards is usually a very gradual process, and conversely the permanency of such a standard is correspondingly secure.

Perhaps the oldest method of expression of ideas by mankind is in poetry, and we ordinarily consider the poet to have a free rein to his imagination, yet most of the great poetry of the world has been expressed in forms which are rigidly standardized and we thus have the seeming paradox that these castles of the imagination are built of blocks and in design of strict specification. One of the most inelastic imaginative structures is the classic Chinese poem; yet we are told the best Chinese poems are not only constructed according to our western ideas of literary form and versification, but they also in themselves are a musical composition with its rigid rules, and constitute a picture as well following the canons of composition of the painter—the Chinese poet is thus necessarily a poet, musician and painter—and so complete, concise and harmonious is the result, his poem cannot be translated into a western tongue to render the whole, because of the limitations of our methods of expression.

In architecture, especially as developed by the Greeks, we see the same rigid rules of composition, a standardization of design and ornamentation; and again as shown in the French cathedrals of the thirteenth century there are superimposed most stringent theological conceptions going into the minutest details and, at first sight, seriously circumscribing the initiative of the artist and builder; nevertheless the Greek temples and Mediaeval churches are recognized as among the marvels of the world from both the structural and aesthetic points of view.

Our survey of the coexistence and interplay of standards and freedom could be extended indefinitely not only in the arts, but we should see the same principles being applied—often with legal penalties for infringement—in the costumes and customs of most peoples. We may mention, as illustrations in passing, the peasants' costumes in many parts of Europe, the restrictive laws of early New England, and above all the practices of the trades' guilds of former times. The thought I wish here to emphasize is this: if the liberal arts have voluntarily imposed upon the creative artist restrictions equivalent to severe standards of many kinds and have nevertheless flourished extraordinarily, in reality freeing and not trammelling the creator, why does the engineer, technologist or industrialist need to fear the effects of standardization on the progress of his more prosaic art? In reality, it is not difficult to demonstrate that standardization does not restrain advances in any branch of human economy but on the contrary liberates energy for improvements.

We may imagine two buildings constructed for similar uses all the materials of which meet the several A.S.T.M. specifications and all the fittings comply with the tenets of simplified practice, and yet these two buildings may be as unlike in design and different in appearance as one could possibly wish.

Again, I understand the American Hotel Association has recently reduced the number of styles of dishes from 700 to 160, but as you go from one hotel to another you will not be able to recognize this standardization and simplification, for the finish and decoration will vary.

Our present industrial chaos, resulting in untold and unnecessary wastes in production and distribution, is largely caused by a lack of understanding, by both producers and consumers, of the benefits to accrue from an intelligent application of the principles of standardization. Our industries have multiplied so rapidly both in number and kind that the brunt of effort has been spent in satisfying the immediate demands for expansion as they arise without giving adequate consideration in most cases to the possibilities of concerted action looking to simplification in type, design and dimensions, and standardization of materials, practice and performance.

We are living, however, in a period of transformation and improvement in this respect, which may be called a renaissance of the standardization ideal and practice; and this period is further characterized by a growing realization by the leaders of industry of the economic advantages to be gained from the elimination of these preventable wastes which are such a severe drain on our resources. Others have said it is a reflection on the engineering profession that it has allowed the existing situation to develop to the present state of confusion, but it is one of the encouraging signs of the times that the profession is now awake to its responsibilities and is making masterful efforts to bring order and economy out of the existing chaos and waste.

Let us consider some of the agencies at work in this field, their inter-relations and what they are trying to accomplish. The files of the American Engineering Standards Committee show there are in the United States some 300 bodies, most of them of national scope, interested in standardization projects. Many of these organizations have under way very extensive programs relating to standards in the engineering and industrial fields. The American Engineering Standards Committee is now functioning normally and efficiently, but with too scant financial support, in its rôle of national supervising agency as to the form and representative character of standards, specifications and codes relating to engineering presented for its approval as American Standards. Not all of the member bodies of the American Engineering Standards Committee, however, yet make a practice of submitting automatically all of the standards of which they themselves approve. The reasons for this reticence are various. It may not be out of place to cite the case of our own Book of Standards which last appeared in 1921, a volume of which we all are proud. Nevertheless, a motion to submit the 1921 Book of Standards for approval as American Standards to the American Engineering Standards Committee was overwhelmingly voted down in your Executive Committee. Why? A single answer cannot be given, but a canvass of our technical committees showed in many instances the desirability of further revision which is now proceeding. Of the 172 standards of the Society 50 have been submitted to the American Engineering Standards Committee, a record not approached by any other organization, and of those so submitted 24 have received the endorsement of that body which means that those standards are recognized and accepted by the whole engineering community in the United States. Many standards have also been withheld by us awaiting joint action by other bodies. The establishment of the American Engineering Standards Committee has been of the greatest service to the American Society for Testing Materials in stimulating more genuinely serious activity on the part of our committees charged with the arduous task of formulating standards and writing specifications fair to the producer and consumer alike, which has always been both our ideal and practice.

At this point I venture to touch again upon a matter emphasized in President Webster's address, namely, the importance of maintaining adequate attendance of representatives of consumers' interests at committee meetings to secure at all times a real balance of producer and consumer in the formulation of standards and specifications. It is possible it may be found desirable to modify slightly our practice by following the example set by the American Engineering Standards Committee in recognizing three instead of two groups in the establishment of standards, the third group to consist of neither producers nor consumers but of disinterested experts representing, for example, testing laboratories and independent engineers. Other modifications of committee procedure, such as curtailing eleventh hour action at the annual meeting, may also be found desirable. A special committee is now at work on this question most vital to the interests of the Society.

Turning now to some of the standardization activities of the Federal Government, in view of the close association of this Society with many of these, it seems appropriate to mention at least some of them. Let us consider, first, the Federal Specifications Board, of which the Director of the Bureau of Standards is *ex officio* chairman. This Board, established by Executive Order under authority of Circular 42 of the Bureau of the Budget dated October 10, 1921, and reporting through the Chief Coordinator to the Director of the Budget, is organized with mandatory powers for the purpose of unifying all government specifications for materials and services other than personal. All government establishments are represented on the Board which functions through technical committees, of which there are 44, which in turn prepare the specifications after consulting as may be deemed advisable by correspondence, conferences or hearings, with representatives of industry. Proposed specifications are also submitted by the Board informally through the American Engineering Standards Committee to industry for comment. When promulgated by the Board these specifications became binding upon all government establishments. Provision is made for appeal by a department to the Chief

Coordinator and a Secretary may, under certain conditions, exempt his Department from using a given specification. Strictly military items are not considered by the Board. To date there have been promulgated 62 specifications; a great many projects are under way and many of these nearing completion. It should be remarked it is not the policy of the Board to formulate new specifications when this can be avoided, and the desire is to bring the government specifications into harmony with our industrial and commercial fabric. The Federal Specifications are evidently buyers' specifications, but they are issued only after representatives of industry have advised they meet current manufacturing conditions and will not require exceptional procedure for furnishing the commodities specified.

The Board has had splendid cooperation on the part of representatives of industry and it is of importance to note that they have shown themselves as ready to call attention to looseness as to stringency in a proposed specification and have evidently taken great professional pride in seeing the Government gets a fair deal. After all, we are all tax payers.

The specifications of the American Society for Testing Materials have been of great use to the Board and many of them have been taken over bodily, such as chemical analysis methods for metals. It should be borne in mind, if one asks why not adopt them all, that it is first necessary to bring into harmony the practices of several governmental bodies which have only just begun to work to a common end. Gradually we may expect a still closer agreement to be reached between the responsible federal and engineering or industrial bodies. It is also of interest to note that the work of the Federal Board has stimulated activity on the part of certain A.S.T.M. committees to bring their specifications up to date, and has shown to the industrial world some serious omissions in the available lists of specifications.

The Department of Commerce is naturally the organization within the Government nearest to industry and commerce, and through the Bureau of Standards has long maintained the closest of contacts with such societies as ours in developing standards and specifications. Much of the work of the Bureau has been along lines of experimental investigation and improvement of testing methods which are so often indispensable before a specification can be framed or applied and many members of the Bureau have been active in the committee work of this Society. This phase of the Bureau's work is familiar to you all and I trust this cooperation may continue to develop to the great benefit of the engineering profession and industry.

Two years ago there was established a Division of Simplified

Practice which has for its object the encouragement of reduction in varieties in our industrial production, about which Mr. Durgin will tell you.

Recently the Secretary of Commerce has considered that more could be done by the Department in the campaign for the elimination of waste in production and distribution, through more concerted cooperation in the application of the practices of unified standards and specifications and that it would be of use to the community to compile and issue what he has called a Dictionary of Specifications based on commodity standards and commercial practices recognized as sound by industry and as fair by the Department. This project is still in the embryonic stage and is being headed up in the Bureau of Standards in liaison with the Commodity Divisions of the Bureau of Foreign and Domestic Commerce and other departmental activities. At first, it is planned to limit this activity to those commodities with which the federal, state and institutional purchasing agencies are concerned. It is hoped also to enlist the active support of industry itself in this movement. It is not expected to duplicate any existing activities but rather stimulate the extension of the specification idea into fields in which the benefits to be gained are not yet appreciated. At a meeting of State Purchasing Agents held in Washington, May 25, it was evident this sort of an appeal for economy and united effort would not fall upon deaf ears. The Department can undoubtedly become of greater service not only to the state and other local governmental purchasing organizations, but to the community as a whole; and there are evidently also opportunities for further service in this field by such societies as this.

For example, a plea was made by some of the states' delegates at that meeting for information regarding the possibilities of the development of simple acceptance tests for materials purchased under specification, and delivered at stations not possessing elaborate testing facilities. This is a problem to which it might be wise for this Society to devote some attention. The same need is voiced by Prof. H. Le Chatelier in one of the chapters of the admirable little book "Réception des Métaux" by Mr. G. Charpy.[1] Professor Le Chatelier gives several illustrations relating to coal, cement, paper and metals of quick simple methods that may be advantageously used even by a semi-technical personnel with little or no testing facilities. The reorganization of our Committee E-1 on Methods of Testing has greatly stimulated the improvement and systematization of our testing methods. This committee might well consider also the question of the scope, development and applications of simple, more rudimentary tests.

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[1] Conditions et Essais de Réception des Métaux, Georges Charpy avec Préface de Henry Le Chatelier. 2nd Ed. Dunod, 1921. Paris.

In considering this phase of our subject—the testing of materials—we may find it advantageous to distinguish between materials which are rapidly consumed and are therefore relatively of transitory interest and those which enter into permanent structures or involve a life hazard. For the first, rudimentary tests for compliance with the specification may often be sufficient, while for the second, rigorously defined and executed acceptance tests may be necessary. This suggestion for the establishment of simple tests is not to be construed as advocating the lowering the standard of our testing methods, but rather the setting up of acceptance tests in many quarters where such are needed but are not now available.

There are two phases of standardization to which we can give but passing notice, nomenclature of terms and form of specifications. These questions are of importance in avoiding confusion and excellent work is being done in the former by this Society both by itself and in association with others. As to the question of form of specifications, it would be desirable to bring about an agreement among all the national specification-making bodies to adopt a single form for a given type, even if there remained outstanding differences in numerical requirements or substance of the specification. This looks difficult of accomplishment, but if it is generally recognized as making for economy and avoidance of confusion, why not try to bring about this unification of form?

Let us pass now to a brief consideration of the relation of research to standardization, with special reference to the activities of our Society. No demonstration is needed before this audience of the intimate and fundamental nature of this relation. We all recognize that material standards are based on the findings of experiment, practice and service, and the numerical values and tolerances—both chemical and physical—inherent in all quantitative specifications cannot, in general, be fairly stated without preliminary research. It is also evident that as the state of the art of production improves, as the quality of raw material available for a given product changes, as new limitations are imposed on the use of a product, for these and many other reasons it follows that our specifications will necessarily always be in a state of revision. The balancing of all these complex, constantly changing factors entails oftentimes a heavy burden of experimental research. Again, there is that intangible but very real factor, a psychological one, of mutual confidence which must be established as between consumer and producer; otherwise penalties will be exacted by one party or the other resulting inevitably in waste. For uncertain knowledge is always certain ignorance and the ignorant buyer is at the mercy of the seller.

Innumerable are the illustrations which might be cited of the intertwining of research with specifications. Perhaps the most striking with which I am familiar, embodying all the factors just mentioned, is the case of the investigation of the effects of variations in the sulfur and phosphorus contents of different grades of steel, carried out with a view to establishing suitable limits of these elements; a subject of great metallurgical and greater economic importance. In the solution of this problem, all interested parties are engaged on a cooperative basis in which all knowledge is pooled through a joint committee working on the unanimous consent basis.

There has been some editorial comment in the technical press asking, in effect, if this elaborate effort and program are worth while, and if the matter should not be turned over to some competent investigator. The answer is that the results of no single investigator will be taken as conclusive by the great specification-making bodies, partly for the reason that this case appears to involve the question of life and engineering hazards, and partly because the independent investigator has not the facilities to carry out the work on the scale required; and if it is done by a manufacturer, however conscientiously, it will not carry the necessary authority. Therefore the only solution appears to be the one we have adopted.

There is an even still broader field of research as related to specifications as illustrated for metallurgical products by the rôle of sulfur and phosphorus in steel, namely, the question which has been answered thus far differently in continental Europe and in America, of simultaneous chemical and physical requirements in many specifications, especially of those relating to metals. If in Europe they can get along satisfactorily without chemical specifications for steel, is it not a waste for us to insist upon them if by so doing we increase the cost of production without getting a more satisfactory product? This question I believe this Society with other specification-making bodies will have to meet some day for certain of the products in which it is interested.

There are undoubtedly many instances in which a limited chemical specification is of value, especially for intermediate products, in that it may be an indicator of physical properties which are in general the characteristics sought in the finished product; or again, for a metal or other material that has to receive additional manufacturing treatments, chemical specification may be more essential than physical.

In other cases, one type of test may be substituted for the other and it then becomes a question which is the more readily and cheaply applied. I have a feeling that in many cases in which both chemical and physical rejection tests are insisted on, this implies ignorance—and not knowledge—on the part of the buyer; and this practice, when the necessity for it is not adequately proved, most certainly results in waste and increased costs. Put in another way, it is always in the interest of economy in the production of items involving large expenditures of capital, to investigate most thoroughly, by experimental research, the adequate basis of our specifications.

The further development of the research activities of our Society both as a basis for specifications and development of testing methods, and also as a part of our charter functions to increase the knowledge relating to the properties of materials, has received the increasing attention of your Executive Committee in recent years, and the time seems now to have come when it appears highly desirable to further stimulate and organize our research work. With this end in view it is planned to organize a committee to make a survey of the situation and devise a plan of procedure which will develop the latent possibilities for organized research which exist within the membership, the committees and affiliations of the Society. Many of our committees have been doing excellent research work, but there has been a tendency on the part of some of them to limit their activities to testing methods and specifications. There are undoubtedly groups and agencies within the Society which if properly encouraged could do a great deal to further our knowledge of the materials in which the Society is interested. One has but to glance over the Engineering Materials Section of the recently issued volume of "Annual Table of Constants" to realize the fact that for most of the technologic materials of industry and commerce, our knowledge of their properties is so inadequate that the writing of specifications is to-day a practical impossibility.

Such a situation is no cause for discouragement but rather an incentive for redoubled effort, through such organizations as this, to intensify and extend our work relating to the determination of the properties of the materials of engineering and industry.

From this brief survey of some of the activities of our Society as related to standardization, testing methods, specifications, and research, we may conclude that in all these fields there are abundant opportunities for further service to the community; and it is to be expected that for the coming quarter century as for the past, in the realm of the materials of engineering and industry the American Society for Testing Materials, always cooperating generously with its contemporaries, will maintain its leadership.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee offers the following report of general Society activities for the past year:

Membership.—Membership statistics for the past year are shown in the following table:

	1922 Annual Meeting	1923 Annual Meeting	Losses				Additions		Totals		
			Transfer	Resignation	Dropped	Death	Transfer	Election	Loss	Gain	Increase
Honorary Members	3	3	..	...	...	..	..	...	...	...	...
Members	2871	3113	..	107	92	13	38	416	210	452	242
Junior Members	156	124	38	9	21	..	..	36	68	36	32[a]
Total	3030	3240	38	116	113	13	38	452	278	488	210

[a] Decrease.

The membership of the Society at the time of this annual meeting is 3240. The net increase in membership for the year is 210, compared with 122 for the year ending with the 1922 annual meeting and 154 for the year ending with the 1921 annual meeting. This gratifying improvement in the net increase in membership was forecast in the Report of the Executive Committee a year ago. The program for increase of Society membership instituted by the Executive Committee early this year, which has been announced to the members in recent A.S.T.M. Bulletins, has played an important part in securing the 452 new members that were elected during the year. This program, it will be recalled, provides for the continued cooperation of each member of the Society in securing desirable new members, and for the creation of Membership Sub-Committees in the various standing committees. The standing committees have cooperated wholeheartedly in this program, and the Executive Committee wishes to express its appreciation to the standing committees and members of the Society who have been endeavoring to interest desirable individuals and companies in supporting the Society and its activities through membership. It is also worthy of note to point out that the number of resignations, 116, is much less than for the previous year (169), which is undoubtedly a direct reflection of improved business conditions.

The Society has suffered the loss by death of thirteen members, among them being Paul Kreuzpointner, the first Treasurer of the American Section of the International Association for Testing Materials, and Rudolph Hering, who held the chairmanship of the Committee on Sewer Pipe during the entire nineteen years since it was organized in 1904. The names of the deceased members are:

C. F. Adam
W. W. Atkinson
E. G. Bashore
William Brady
F. J. Cole
W. R. Dawson
Rudolph Hering
A. L. Johnson
Paul Kreuzpointner
S. B. Newberry
A. A. Remington
C. J. Tagliabue
W. R. Walker

Membership growth since the organization of the Society is shown in Fig. 1.

Standing Committees.—As in past years, the standing committees of the Society have been quite active, and many valuable reports are announced on the program of this meeting. Of the 39 standing committees, all but four are presenting reports, of which six are in the nature of brief formal reports of progress. The reports presented comprise approximately 562 pages and include recommendations for proposed revisions in 23 standards (of which 4 have been previously reported), adoption of 21 tentative standards as standards, acceptance of 43 proposed new standards as tentative, and proposed revisions in 51 tentative standards to be continued as tentative.

During the year, one change in committee organization has been made, namely, the consolidation of the former Committee D-5 on Coal and Committee D-6 on Coke into a single committee now designated D-5 on Coal and Coke. This change was made by the Executive Committee upon the unanimous recommendation of both committees concerned and will result in more efficient operation of the Society's studies of coal and coke.

A suggestion that the Society organize a Committee on Ferro-Alloys was mentioned in the report of last year. Subsequent developments have convinced the Executive Committee that there is need for the formulation of methods of sampling and analysis of and specifications for ferro-alloys, both producers and consumers of such alloys having expressed this view and agreed to serve upon the committee if organized. Accordingly, the Executive Committee has created Committee A-9 on Ferro-Alloys and it is expected to effect the organization of the committee in the fall in accordance with the procedure stipulated in the Society's Regulations.

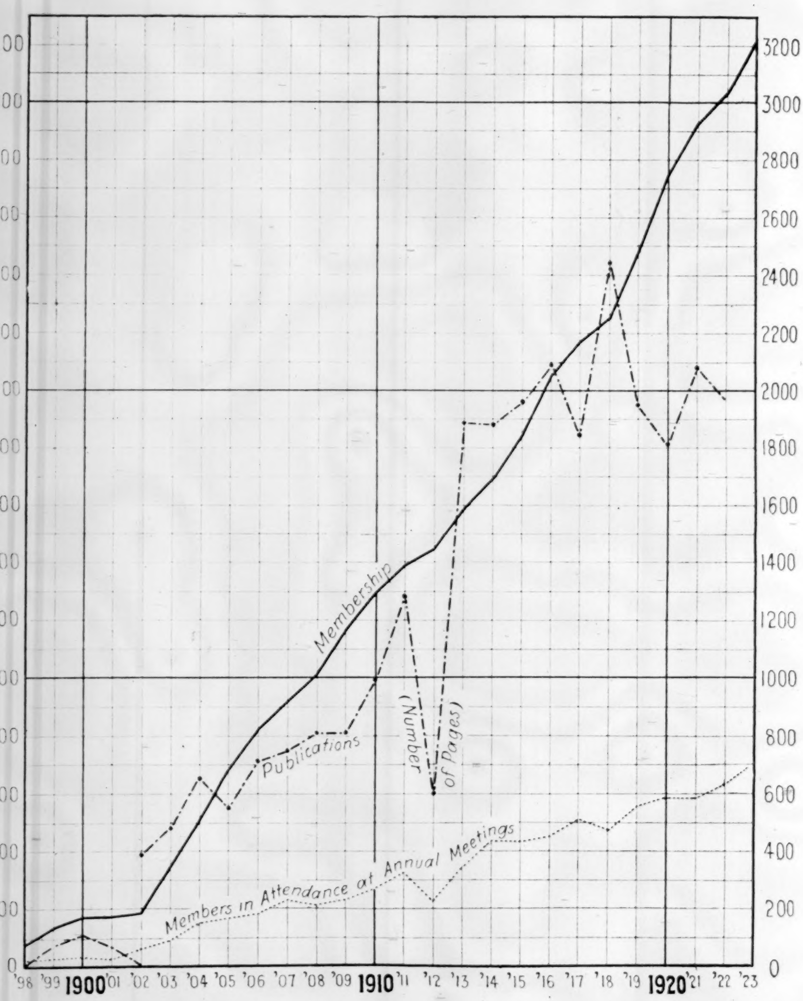

FIG. 1.—Membership and Publications Chart.

NOTE.—The initial curve for publications (1898–1902) refers to the publications of the American Section of the International Association for Testing Materials. The marked drop for 1912 in the "publications" and "members in attendance at annual meetings" curves is due to the fact that the Sixth Congress of the International Association was held in New York in September, 1912, and that the activities of the American Society for that year were accordingly restricted to committee reports and administrative business.

Other subjects that have been suggested for consideration by new standing committees are those of Slate and Testing of Glue. The Executive Committee has deferred decision in the matter of organizing committees on these subjects and will take into consideration during the year the discussion that will be had of the papers on these two subjects that are announced on the program of the annual meeting. Likewise, the organization of committees on Leather Belting and on Asbestos and Magnesia Products is still under consideration.

Committee B-2 on Non-Ferrous Metals and Alloys has suggested the appointment of a Committee on Corrosion-Resistant, Heat-Resistant and Electrical Alloys. The field covered by such a committee is of interest to several of the present standing committees, who will be consulted during the year regarding this suggestion.

During the year the Association of American Steel Manufacturers requested the Society to undertake the preparation of Specifications for Oil Country Tubular Goods. The request was referred to Committee A-1 on Steel, which is taking steps to prepare such specifications with the cooperation of the American Petroleum Institute and individual oil companies.

A recommendation from the Portland Cement Association that the Society consider the preparation of Specifications and Tests for Cloth Cement Bags has been referred by the Executive Committee to Committee D-13 on Textile Materials for consideration and recommendations.

Publications.—The regular publications during 1922 were the Proceedings, Supplement to the Book of Standards, and the Year Book. The comparative statement of the volume of regular publications during the past three years is as follows:

	1920, PAGES	1921, PAGES	1922, PAGES
Proceedings	1359	1197	1614
Book of A.S.T.M. Standards	...	890	...
Year Book (Membership List)	320	...	304
Supplement to Book of Standards	128	...	54
Supplement to Year Book	...	32	...
Total	1807	2119	1972

In addition, the Society published in 1922 the Book of A.S.T.M. Tentative Standards (774 pages). Since the Proceedings, by action two years ago, now contain only new and revised tentative standards, the Book of A.S.T.M. Tentative Standards is the only publication containing the complete collection of the tentative standards. It is furnished to members upon order, and the demand for the volume has been so gratifying that its publication will be continued as a matter of regular policy.

There was also published early in 1923 the Index to Vols. XIII to XX (1913–1920) of the Proceedings (189 pages). A List of Alloys (30 pages) was reprinted for separate sale from the report of Committee B-2 on Non-Ferrous Metals and Alloys in the 1922 Proceedings and is now in second printing.

The A.S.T.M. Bulletin has been issued quarterly (July, October, January and April) and is now an established publication of the Society. There have also been printed during the year four circulars to members in addition to the issues of the Bulletin.

The bound publications issued since the last annual meeting, not including reprints, total 2935 pages.

Headquarters.—The facilities offered by the Society headquarters for meetings of committees and their sub-committees have been very generally used. During the period from June, 1922, to June, 1923, there were 30 committee meetings, 41 sub-committee meetings and 9 meetings of committees of other societies, or a total of 80. The Executive Committee wishes to have the committees and members of the Society make use of the Society headquarters as much as possible.

The lease on the present headquarters expires December 31, 1924. The Executive Committee is negotiating with the Engineers' Club of Philadelphia for a renewal of the lease and is also endeavoring to secure additional space required by the growth of the Society's work and the resulting necessary expansion in office personnel and equipment.

Finances.—The annual statement of the finances of the Society follows in the form of the report of the auditors for the fiscal year January 1, 1922, to December 31, 1922.

The surplus on December 31, 1922, was $33,028.17 and includes $1300 life membership dues, $1467.17 for rent paid in advance,[1] $2825.92 for furniture and fixtures and $4200 set aside as a sinking fund towards defraying the cost of the 1924 issue of the Book of Standards.

Receipts from the sale of Society publications for 1922 were $18,258.83, compared with $18,033.56 for 1921 and $10,983.37 for

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[1] When the Society established its headquarters in the fall of 1919, it entered into an agreement with the Engineers' Club of Philadelphia by which it was to pay the cost of necessary alterations to the Club building, this sum to be accepted by the Club as advance payment of rent at the rate of $1000 a year. This agreement became effective on January 1, 1920. The total amount thus paid by the Society was $4467.17, of which $3000 has been charged off in the three years ended December 31, 1922, leaving the amount on that date of $1467.17 as an asset.

Report of Auditors for the Fiscal Year January 1, 1922, to December 30, 1922.

JOHN HEINS AND CO.
PUBLIC ACCOUNTANTS AND AUDITORS

Philadelphia, January 2, 1923.

American Society for Testing Materials,
Mr. C. L. Warwick, *Secretary-Treasurer,*
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 30, 1922, having previously made a similar audit and report for the preceding six months ended June 30, 1922, and at both audits found the accounts to be correct and to be in their usual excellent condition.

We submit balance sheet as of December 30, 1922, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the last six months as also for the six months ended June 30, last, as reported in ours of July 21 and found the same to be correct.

We have verified by actual inspection and count the securities as listed on the Balance Sheet.

Respectfully submitted,
(Signed) John Heins and Co.

BALANCE SHEET AS OF DECEMBER 30, 1922.

Assets.

Cash		$3,495.03	
Investments:			
$13,000 U. S. Liberty Loan Bonds, 4th $4\frac{1}{4}$'s	$12,486.03		
4,200 U. S. Liberty Loan Bonds, 4th $4\frac{1}{4}$'s, reserve for 1924 Book of Standards	3,894.61		
1,300 U. S. Liberty Loan Bonds, 4th $4\frac{1}{4}$'s, held for Life Membership Fund	1,227.45		
3,000 P. R. R. Equipment Bonds, 6's, due 1933	3,052.56		
		$20,660.65	
Accounts Receivable:			
For Publications	$2,865.65		
Members for 1922 dues	2,339.50		
Members for binding	37.50		
		5,242.65	
Rent paid in advance		1,467.17	
Furniture and Fixtures		2,825.92	
			$33,691.42

LIABILITIES.

Members' dues paid in advance	$443.00		
Members' binding paid in advance	4.50		
Publications paid for in advance	215.75		
		$663.25	
Life Membership	$1,300.00		
Surplus	31,728.17		
		33,028.17	
			$33,691.42

MISCELLANEOUS FUNDS.

In addition to the above cash the Secretary-Treasurer has on hand the following funds:

Committee A-5 on Corrosion of Iron and Steel	$1,949.73	
Committee C-1 on Cement	2,046.99	
Committee C-9 on Concrete and Concrete Aggregates	586.23	
Committee C-10 on Hollow Building Tile	198.29	
Committee D-1 on Preservative Coatings	121.14	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	160.17	
		$5,062.55

RECEIPTS AND DISBURSEMENTS.
JANUARY 1, 1922, TO DECEMBER 30, 1922.

Cash on hand, January 1, 1922			$3,819.07

RECEIPTS.

Current dues	$42,960.12		
Past dues	674.20		
Advance dues	428.00		
		$44,062.32	
Sale of Publications:			
Separate Standards	$3,261.08		
Book of Standards	4,356.75		
Book of Tentative Standards	3,605.84		
Proceedings	3,212.30		
Miscellaneous	3,822.86		
		18,258.83	
Binding (Members)		502.00	
Sale of right to reprint Standards		700.00	
Authors' reprints		119.29	
Sale of Certificates of Membership		30.00	
Interest on deposits and investments		1,721.81	
Accrued interest		180.10	
Excess remittances		53.25	
Committee A-5		250.00	
Total receipts		$65,877.60	65,877.60
			$69,696.67

Brought Forward		$69,696.67

DISBURSEMENTS.

Publications	34,752.78	
Salaries	17,723.20	
General Office Expenses	3,877.81	
Expenses, Standing Committees	1,346.62	
Expenses, Annual Meeting	1,872.29	
Expenses, Nominating Committee	35.81	
Traveling Expenses, Executive Committee	552.80	
Rent and Insurance, Storage Rooms	321.60	
Rent Additional Room	120.00	
Headquarters' Maintenance	158.57	
Furniture and Fixtures	485.75	
Certificates of Membership	65.50	
American Engineering Standards Committee	1,500.00	
Investments	3,052.56	
Accrued interest	180.10	
Refund of excess remittances	53.25	
Miscellaneous	103.00	
Total disbursements	$66,201.64	66,201.64
Cash on hand December 30, 1922		$3,495.03

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1918–1922, INCLUSIVE.

Fiscal Year.	Assets.					Liabilities.	Surplus.
	Cash Balance.	Investment.	Accounts Receivable.	Advance Rent and Furniture and Fixtures.	Total.	Accounts Payable.[a]	Surplus.[b]
1918	$7 164.93	$4 880.63	$2 569.95	....	$14 615.51	$331.47	$14 284.04
1919	294.70	15 601.58	3 415.40	$3 600.00	22 911.68	417.25	22 494.43
1920	265.05	17 608.09	3 823.90	5 897.48	27 594.52	2 608.50	24 986.02
1921	3 819.07	17 608.09	5 218.35	5 121.34	31 766.85	770.00	30 996.85
1922	3 495.03	20 660.65	5 242.65	4 293.09	33 691.42	663.25	33 028.17

[a] These sums represent dues and publications paid in advance and do not include any unpaid bills except for 1920, a loan of $2200 from the Girard Trust Company.

[b] These items include $1300 on account of Life Memberships.

1920. Receipts from this source now constitute slightly over one-fourth the total receipts of the Society, the percentage for this year being 26.2, compared with 27.6 in 1921 and 19.1 in 1920. It should be noted that it is essentially these increased receipts from sales of publications that have enabled the Society to maintain the publication of Proceedings, Standards and Tentative Standards practically without curtailment in the face of greatly increased printing costs.

Thus, 55 per cent of the disbursements for 1922 (exclusive of investments) were for the mechanical costs of publications, that is, exclusive of all overhead expenses, and the Society's printing in that year cost approximately 60 per cent more page for page than it did in 1916, which was the last normal cost year in the printing industry.

Inventory of Publications in Stock.—In the foregoing financial analysis no account has been taken of the assets of the Society in the form of publications in stock. The inventory on May 15, 1923, may be summarized as follows:

	NUMBER OF COPIES
Proceedings	8027
1921 Book of A.S.T.M. Standards	1954
Index (Vols. I–XII, incl.)	597
(Vols. XIII–XX, incl.)	747
Reports of Committee D-1 (1903–1914 incl.)	299
1922 Book of A.S.T.M. Tentative Standards	190

Distribution of Preprints.—In accordance with the decision of the Executive Committee announced at the last annual meeting, the new plan of distributing preprints has been put into effect this year for the first time, namely, to mail in advance of the meeting only those committee reports and papers that members have requested be sent to them and to distribute a complete set of preprints of reports and papers to each member attending the annual meeting. So far as can be seen at this time, this plan has been favorably received by the members, and while it has created some new problems of distribution, these have been worked out successfully, so that the saving of approximately $1500 in the Society's preprint bill estimated for the budget this year, is fully expected to be realized.

Rotation of Annual Meetings.—The Executive Committee has fully considered during the year the plans of rotation of annual meetings and of holding semi-annual meetings, referred to at some length in the last annual report. In the October, 1922, Bulletin, in announcing the selection of Atlantic City as the place of meeting for this year, the Executive Committee stated that since two meetings annually, held at different places, would provide the rotation of meetings recommended by a number of members, the two plans were being considered in their mutual relations. Despite the increasing pressure at the annual meetings that comes from the steadily increasing number of reports, papers and discussions that must appear on the program if the Society is to cover at all adequately the field that it has marked out for itself, the Executive Committee feels that the Society is hardly prepared at the present time to adopt the suggested solution, to relieve this situation, of holding two meetings annually. Such important considerations as the added financial expense of a second meeting and the objection of introducing into the general engineering society fabric another society meeting to be attended, making additional demands upon busy men, have influenced the Executive Committee in this decision. As a temporary expedient, the Executive Committee has authorized the Committee on Papers and Publications to add to the number of sessions in the annual meeting, extending the length of the meeting if necessary, and to continue if desired the holding of simultaneous sessions. It is fully realized that at the present rate of growth of Society activities even this expedient has limitations if the length of the annual meeting is to be held within reasonable, practicable bounds and the number of simultaneous sessions kept at a desirable minimum, and that the plan of meeting semi-annually may have to be reconsidered in the light of future developments.

The Executive Committee has decided that for the present it is to the best interests of the Society not to adopt a plan of rotation of annual meetings as a fixed policy, but to continue instead the present policy as defined in the By-laws, by which the Executive Committee determines annually the time and place of meeting. The obvious advantages of a seaside resort for meeting in June—the month for which the members have expressed practically unanimous preference—are well known, and have been evidenced for many years by the successful, well-attended meetings that have been held. The considerations that have been advanced in favor of rotation of meetings, such as stimulation of interest in Society work in various districts throughout the country in which meetings might be held, making it possible for members in such districts to attend annual meetings more frequently, obtaining more general adoption of the Society's standards, and others, have all been weighed carefully; and despite the vote of 305 to 182 in favor of rotation, as indicated by a questionnaire in October, 1921, the Executive Committee recommends that the existing policy be continued for the present. In making this recommendation the Executive Committee has in mind the possibility that the growth of the Society activities previously referred to may require, in the not distant future, consideration of the entire scheme of Society and committee meetings, and that at this particular period of our development it is not advisable to make so marked a change in policy.

Future Development of Society Activities.—The Society's activities are along two broad lines. As defined in the Charter, these are the promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing. In the twenty-five years of its existence, the Society has perfected methods of formulating standards as exemplified by the provisions in the Regulations Governing Standing Committees, under which upwards of thirty-five committees are now successfully developing standards in their respective fields. In the past two or three years, such important matters as proper correlation of the Society's work in developing methods of testing and establishing standard nomenclature and definitions have been worked out through the reorganization of Committee E-1 on Methods of Testing and the creation of a new Committee E-8 on Nomenclature and Definitions. It is well known that standardization in a broad sense has been receiving a good deal of attention within the past five years, as exemplified by the work of such groups as the American Engineering Standards Committee, the Specifications Board of the Government, and the Division of Simplified Practice of the Department of Commerce.

It has been pointed out in previous reports of the Executive Committee that the other function of the Society, that is, the promotion of knowledge of engineering materials, has not been developed in the same way nor to the same degree. By acting as a forum for the presentation and discussion of technical papers dealing with the properties of materials and their behavior in service, the Society has brought together in its Proceedings a great deal of useful and valuable information about materials. The work of some of the Society's committees, moreover, is directed specifically to this end, in some instances practically to the exclusion of any so-called standardization work. The Committee on Papers and Publications, in formulating the program for the last two annual meetings, has made special efforts to provide opportunity for discussion of important topics, in such a way as to bring out valuable information and make it more readily available for reference. The committee has also sought to secure papers on subjects about which there is urgent need of reliable data, and the Executive Committee believes that the program this year is in this respect probably the most significant that has ever been arranged for our meetings.

Notwithstanding, the Executive Committee feels that there is still a great deal that the Society should do more fully to develop this important side of its work. The Society should consciously, in as systematic and concerted a way as possible, go about the task of extending the knowledge of engineering materials, their properties, their performance in service, and the correlation of properties and performance that determine the suitability of various materials for specific services, about which there is still a great deal to be learned.

Certain kinds of problems can properly be handled by existing committees; in fact certain committees are at work at present on just such problems. Realizing, however, that study and research is needed in the fields covered by the Society's activities, the Executive Committee has under consideration the appointment in the Society of a small Committee on Research, whose duty would be to review these various fields and point out wherein the Society might engage in appropriate ways in certain studies that the Committee on Research finds are needed. Such a committee would not conduct research; it would advise and recommend. The Executive Committee has authorized the President to appoint such a committee, but it has been thought desirable in view of the importance of the question to have the President, as a separate order of business on the program of the annual meeting, discuss broadly the relation of the Society to research in engineering materials. Such an arrangement has been made and the Executive Committee hopes for a full discussion of the subject by the members.

Materials Engineering Education.—In 1921, the Executive Committee discussed briefly the importance of the problem of engineering education in relation to the study of materials in the engineering and technical schools of the country. At that time it was decided to appoint a small standing committee on Materials Engineering Education to study this problem as it relates to the Society's activities. The Executive Committee experienced considerable difficulty in securing members of the desired qualifications for this committee, not because of lack of interest in the subject of engineering education, but because the problem was being treated more broadly and in what is now considered a more satisfactory fundamental way in such groups devoted specifically to the subject, as the Society for Promotion of Engineering Education (with which national engineering societies have been cooperating) and through the activities within the last few years of such other groups as the National Industrial Conference Board, which has taken a considerable interest in educational problems. Moreover, the general trend of engineering ideas to-day is rather perceptibly in the direction of broadening engineering courses as much as possible, and the Executive Committee considers that it would be unwise for the Society even to appear to suggest further specialization that would be required should more time be given to the subject of engineering materials. The Executive Committee has accordingly rescinded its previous action, although it has under consideration other means of calling the attention of engineering educators and graduate students to the importance of the materials engineering field.

American Engineering Standards Committee.—Past-President C. D. Young has been appointed to fill the unexpired term as one of the Society's representatives occasioned by the death of Past-President A. W. Gibbs.

Members of the Society have been kept acquainted through the A.S.T.M. Bulletin with the activities of the Society and its committees in relation to the work of the American Engineering Standards Committee. In the last annual report it was noted that one standard of the Society had been approved as American Standard and thirteen as Tentative American Standard. Since that time ten more standards of the Society have been approved as Tentative American Standard, as follows, making a total of 24:

Standard Methods of:
- Chemical Analysis of Lead, Tin, Antimony and Copper (B 18 – 21);
- Test for Unit Weight of Aggregate for Concrete (C 29 – 21);
- Test for Voids in Fine Aggregate for Concrete (C 30 – 22);
- Test for Organic Impurities in Sands for Concrete (C 40 – 22);
- Test for Penetration of Bituminous Materials (D 5 – 21);
- Routine Analysis of White Pigments (D 34 – 17);
- Laboratory Sampling and Analysis of Coke (D 37 – 21);
- Routine Analysis of Dry Red Lead (D 49 – 18);
- Routine Analysis of Yellow, Orange, Red and Brown Pigments containing Iron and Manganese (D 50 – 18);
- Test for Flash Point of Volatile Flammable Liquids (D 56 – 21).

The Society has been designated as sponsor for nine of these and as joint sponsor with the U. S. Bureau of Public Roads, American Association of State Highway Officials and American Society for Municipal Improvements for the Standard Method of Test for Penetration of Bituminous Materials (D 5 – 21). In addition, the Society has assumed sponsorship to the Standards Committee for eight of the standards reported last year as having been approved, of the following serial designations: A 32 – 14, A 54 – 15, B 3 – 15, B 4 – 13, B 5 – 13, B 34 – 20, C 9 – 21, D 21 – 16. The Society has also been designated as joint sponsor with the U. S. Bureau of Standards and the Fire Protection Group of the A.E.S.C. for Specifications for Fire Tests of Materials and Construction (C 19 – 18) reported last year as having been approved as Tentative American Standard. Since revision of these specifications are in contemplation, immediate steps are being taken to organize a representative sectional committee under the rules of the Standards Committee.

The following 26 standards of the Society have also been submitted to the Standards Committee for approval as Tentative American Standard and are now receiving consideration:

Standard Specifications for:

- Carbon-Steel and Alloy-Steel Blooms, Billets and Slabs for Forgings (A 17 – 21);
- Carbon-Steel and Alloy-Steel Forgings (A 18 – 21);
- Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19 – 21);
- Carbon-Steel Forgings for Locomotives (A 20 – 21);
- Carbon-Steel Car and Tender Axles (A 21 – 18);
- Cold-Rolled Steel Axles (A 22 – 21);
- Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives (A 63 – 21);
- Carbon-Steel Bars for Railway Springs (A 14 – 16);
- Helical Steel Springs for Railways (A 61 – 16);
- Elliptical Steel Springs for Railways (A 62 – 16);
- Welded and Seamless Steel Pipe (A 53 – 21);
- Welded Wrought-Iron Pipe (A 72 – 21);
- Refined Wrought-Iron Bars (A 41 – 18);
- Wrought-Iron Plates (A 42 – 18);
- Staybolt, Engine-Bolt and Extra Refined Wrought-Iron Bars (A 84 – 21);
- Manganese-Bronze Ingots for Sand Castings (B 7 – 14);
- The Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent (B 10 – 18);
- Copper Plates for Locomotive Fireboxes (B 11 – 18);
- Free-Cutting Brass Rods for Use in Screw Machines (B 16 – 18);
- Naval Brass Rods for Structural Purposes (B 21 – 19);
- Brass Ingot Metal, Graded and Ungraded, for Sand Castings (B 30 – 22);
- Solder Metal (B 32 – 21);
- High Sheet Brass (B 36 – 21);
- Purity of Raw Linseed Oil from North American Seed (D 1 – 15);
- Purity of Boiled Linseed Oil from North American Seed (D 11 – 15);

Standard Methods of:

- Testing Cotton Fabrics (D 39 – 20).

Thus, a total of fifty standards of the Society have been placed before the Standards Committee for consideration and others will be submitted by the Executive Committee as they are recommended for that purpose by the several standing committees.

In addition to the sponsorships noted above and those reported a year ago, the Society has been designated sponsor for the development of Methods of Testing Petroleum Products and Lubricants and is taking steps to organize a sectional committee. The Society has been designated joint sponsor with the Federal Specifications Board for the development of Specifications for Linseed Oil, this having been the outcome of the action of the Society in submitting its specifications D 1 – 15 and D 11 – 15 to the Standards Committee as above noted. The Society is joint sponsor with the Society of Automotive Engineers for the development of a system of numbering steels based upon specifications, and the first steps have been taken towards organizing a sectional committee on this subject. The Society has also indicated its preparedness and desire to act as sponsor for the development of Methods of Testing Textiles. This request is still under consideration.

As reported in the January Bulletin, the Society and the U. S. Forest Service as joint sponsors completed the organization of the Sectional Committee on Methods of Testing Wood at a meeting held in Washington on December 13, 1922. The following statement of the scope of the committee's activities was adopted:

> "The scope of the committee's activities embraces the standardization of methods of physical (including mechanical) tests of wood. The most important desideratum involved is the establishment of standard practice in testing wood which will make data obtained at different sources of the broadest possible value and insure the attainment of comparable results. Of immediate importance is the application of these methods to (*a*) small clear specimens, and (*b*) structural sizes.
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> "The committee will not formulate methods of test of articles manufactured of or fabricated from wood, such as boxes, barrels, axe handles, wooden trusses, etc., except as may be necessary in the study of tests to determine physical properties of wood."

The work of Committee D-7 on Timber is well tied in with that of the Sectional Committee. The Society's representative on the Sectional Committee, M. O. Withey, is a member of Committee D-7, serving as secretary of the Sectional Committee. L. J. Markwardt, appointed by the U. S. Forest Service, is chairman of the Sectional Committee and is also chairman of the Sub-Committee on Methods of Testing, of Committee D-7 on Timber. At the organization meeting the Society offered for consideration of the Sectional Committee the A.S.T.M. Tentative Methods of Testing Small Clear Specimens of Timber, and these methods are being studied as the first problem of the committee.

During the year the following appointments were made of representatives of the Society on sectional committees under the sponsorship of other organizations: F. M. Waring and J. J. Shuman as representatives on the Sectional Committee on Standardization of Shafting, under the sponsorship of the American Society of Mechanical Engineers; and the Secretary-Treasurer as representative on the Sectional Committee on a Safety Code for Compressed Air Machinery, under the joint sponsorship of the American Society of Safety Engineers and the American Society of Mechanical Engineers.

Cooperation with the Federal Specifications Board.—During the year a plan has been worked out by which specifications prepared by the Federal Specifications Board are submitted in tentative form to the American Engineering Standards Committee for the purpose of securing informal criticisms and comments on the specifications by the industries concerned. This the Standards Committee is able to do through its intimate contact with industrial and technical organizations. These specifications are transmitted by the Standards Committee to individuals whose names are suggested by various national organizations, and the Standards Committee forwards to the Federal Specifications Board all criticisms and comments received and these are reviewed by the Board before the specifications are finally promulgated. In this way the Society has been instrumental in securing criticisms of the following F. S. B. specifications: Hose, Numbered Cotton Duck, Creosote Oil, Coal-Tar Pitch for Roofing, Pig Lead, Silicon Copper, Ingot and Phosphor Copper, Ingot Tin, Slab Zinc, Gray Iron, High-Test Gray Iron and Steel Castings, and Foundry Pig Iron.

Division of Simplified Practice of the U. S. Department of Commerce.—The Society has maintained contact with the Division of Simplified Practice in connection with some of the Division's projects in which we are interested. The Society is represented on a committee considering the elimination and standardization of sizes of paving brick, and reference to the work of that committee is contained in the annual report of Committee C-3 on Brick. Some work this year by Committee C-6 on the elimination of certain sizes of drain tile, described in the committee's annual report, has been carried out with the expectation that at an opportune time the work will be extended to apply to other classes of pipe and the whole project developed under the auspices of the Division. Recent conferences called by the Division in which the Society is interested have dealt with simplification of certain kinds of clay products, *e.g.*, sewer pipe and drain tile, and reduction in varieties of asphalt.

Lumber Standardization.—Recent issues of the A.S.T.M. Bulletin have carried announcements regarding a most significant standardization movement in the lumber industry. This movement had its inception in the first American Lumber Congress in 1919 and was brought to a head by a conference in May, 1922, called under the auspices of the U. S. Department of Commerce. The outcome of this conference was the appointment of a Central Committee on Lumber Standards representing the entire organized lumber trade from producer to consumer, whose function is to act as a steering organization to draft and submit to the constituent associations "its best judgment of suitable ways and means to accomplish in practice the simplification of lumber grades, the standardization of lumber sizes, the certification of quantity and quality, and the enforcement, by means of association inspection service and, if practicable, by grade marking, of definite standards of lumber sizes and grades." This committee has created a Consulting Committee, consisting of representatives of national organizations interested in this program, to prepare appropriate data and suggestions for consideration of the Central Committee. The Society has taken an active part in the work of this Consulting Committee, being represented thereon by Hermann von Schrenk, A. F. Robinson and C. C. Warne, all members of Committee D-7 on Timber. Reference to the activities of the Central Committee will be found in the annual report of Committee D-7.

Division of Engineering, National Research Council.—Past-President J. A. Capp has been re-appointed as one of the Society's representatives for a term of three years. Through its representatives the Society has continued to maintain contact with the work of the Advisory Board on Highway Research, the Committee on Corrosion and, informally, the Committee on Hardness Testing of Metals. F. N. Speller has been appointed as one of the Society's representatives on the Committee on Specifications for Steel to be Welded, of the American Bureau of Welding, which is one of the advisory boards of the Division of Engineering. Mr. Speller succeeds H. L. Whittemore, resigned, and jointly with E. F. Kenney keeps the Society's Committee A-1 on Steel in contact with the Bureau's committee. The Engineering Division's Committee on Heat Treatment has recently been reorganized and the Society has designated H. M. Boylston and J. H. Hall, chairman and secretary respectively of our Committee A-4 on Heat Treatment of Iron and Steel, as its representatives on the committee.

Cooperation with the A.S.M.E. Boiler Code Committee.—The Society has continued its cooperative work with the American Society of Mechanical Engineers in the matter of specifications for materials to be included in the revised edition of the Boiler Code of that Society. Two meetings of the joint committee designated for the purpose were held, at the second of which representatives of the various A.S.T.M. committees interested were present for consultation. As a result, very gratifying agreement has been reached in the material specifications, which may be briefly summarized as follows:

The Boiler Code Committee has adopted general Rules for Inspection and Test which are based upon similar requirements in A.S.T.M.

specifications. Specifications for Steel Boiler Plate agree essentially with corresponding A.S.T.M. specifications; there is still to be adjusted a question of additional chemical check analysis on firebox steel, now under consideration by the Society and the Association of American Steel Manufacturers. Specifications for Steel Boiler Rivets also agree, in general, with corresponding A.S.T.M. specifications; the A.S.M.E. specifications, however, include proposed permissible tolerances for finished rivets, for which the A.S.T.M. has not as yet provided requirements. Specifications for Steel Staybolts and for Steel Bars cover special materials for which Committee A-1 has not deemed it advisable to prepare specifications. Specifications for Steel Castings agree in their essential requirements with the Society's specifications as it is proposed to revise them this year. Specifications for Boiler Rivet, Staybolt and Refined Bar Iron are in essential agreement with corresponding A.S.T.M. specifications, save that the Society has not written specifications for rivet iron. Specifications for Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes, for Gray-Iron Castings, for Malleable Castings, for Copper Plates, for Copper Bars for Staybolts, and for Seamless Copper Boiler Tubes are based entirely upon the corresponding A.S.T.M. specifications of the same titles.

Wherever possible, as, for example, in the case of the last six specifications, the A.S.T.M. requirements have been adopted verbatim; and it is believed that material passing the several A.S.T.M. specifications (some of them with revisions that are being proposed at this meeting) will in practically all cases conform to the requirements of the Boiler Code as it is expected to be revised. In view of the legal status that the Boiler Code has in many of the states, this cooperative work has a great deal of significance to the Society and the hearty spirit of cooperation that has been evidenced throughout the work of the Joint Committee is very gratifying.

Cooperation with American Foundrymen's Association.—During the year, the Executive Committee reached an agreement with the Board of Direction of the American Foundrymen's Association regarding details of cooperation between the two societies with respect to specifications and methods of test of mutual interest. This agreement has been expressed in the following articles:

(*a*) That the American Foundrymen's Association be elected to membership on those A.S.T.M. committees dealing with specifications and methods in which the A.F.A. is interested;

(*b*) That the chairmen of the A.F.A. committees be designated as the representatives on the sub-committees of the appropriate A.S.T.M. committees;

(*c*) That the A.F.A. committees function by reviewing A.S.T.M. specifications as they stand, either by recommending endorsement by the A.F.A. or submitting criticisms for transmittal to the A.S.T.M. committees; that with respect to existing A.S.T.M. tentative specifications, endorsement be deferred until their adoption as standard and that in the meantime any criticisms of such specifications should be transmitted to the A.S.T.M. committees;

(*d*) That with reference to publication by the A.F.A. of A.S.T.M. specifications, publication take the form of an endorsement of such specifications, which will be printed as A.S.T.M. specifications.

In pursuance of this agreement the American Foundrymen's Association is now represented on the following committees of the Society: A-1 on Steel, A-3 on Cast Iron, A-4 on Heat Treatment of Iron and Steel, A-5 on Corrosion of Iron and Steel, A-7 on Malleable Castings, B-2 on Non-Ferrous Metals and Alloys, C-8 on Refractories, D-5 on Coal and Coke and E-4 on Metallography.

As one of the developments of this plan, the Executive Committee has under consideration with the Board of Direction of the A.F.A. the question of appointment of a joint committee to discuss international foundry matters, particularly an international test bar for cast iron. The A.F.A. is in communication with certain foundrymen's associations abroad and an agreement has been reached that any plans looking towards the adoption of international standards should be carried out through the medium of the American Engineering Standards Committee.

Miscellaneous Joint Committees.—The Society has continued during the past year its participation in the work of the various joint committees upon which it is represented. Special mention should be made of the work of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel, which has made considerable progress in the study of the effect of sulfur in structural steels and which expects to report at this annual meeting on a special series of structural, forging and rail steels containing both added and residual sulfur. The Joint Committee on Standard Specifications for Concrete and Reinforced Concrete has been quite active and an informal report of the progress of its work will be made at the annual meeting.

Other Cooperative Work.—Among other cooperative work that has taken place this year might be mentioned the following:

Committee B-2 on Non-Ferrous Metals and Alloys is cooperating with the National Electric Light Association in the consideration of specifications for condenser tubes. Committee B-1 on Copper Wire will bring out this year specifications for trolley wire that have been prepared in cooperation with the American Electric Railway Association. Definitions of terms relating to heat treatment are being jointly considered by a committee of the A.S.T.M., the Society of Automotive Engineers and the American Society for Steel Treating. The British Electrical and Allied Industries Research Association has submitted a number of helpful criticisms and comments regarding the Society's methods for determining the dielectric strength of transformer and switch oils and other insulating materials. These have been referred to Committee D-9 for consideration, and correspondence has been exchanged between the committee and the Association.

International Engineering Congress in Brazil.—The Society was represented at the International Engineering Congress in Brazil by W. E. Emley of the U. S. Bureau of Standards, who was one of the official Government delegates. Upon Mr. Emley's recommendation, a complete set of the Society's Proceedings, Standards and Tentative Standards was exhibited at the Congress and then presented to the Club de Engenharia, Rio de Janeiro. This gift has been courteously received and acknowledged and the Executive Committee has decided to send current publications to the Club, so that an up-to-date file of the Society's publications will be available.

International Engineering Congress in 1926.—It is planned to hold an International Engineering Congress in 1926 in connection with the Sesqui-Centennial Exhibition to be held in Philadelphia that year in anniversary of the 150th year of independence of the United States. The Executive Committee has voted that the Society should hold an international meeting on the subject of engineering materials during that year and is conferring with the board of management of the International Engineering Congress on ways and means by which this meeting can properly be made a part of the International Engineering Congress.

Respectfully submitted on behalf of the Executive Committee,

GEORGE K. BURGESS,
President.

C. L. WARWICK,
Secretary-Treasurer.

DISCUSSION ON RESEARCH

[Following the presentation and adoption of the annual report of the Executive Committee, the chairman, President-elect Guilliaem Aertsen, invited the President, George K. Burgess, to open the discussion on the proposal contained in the report of the Executive Committee[1] to create in the Society a Committee on Research.]

The President

THE PRESIDENT (GEORGE K. BURGESS).[2]—I have not prepared a written statement on this matter of research. The question is briefly this: the Executive Committee, as stated by the Secretary-Treasurer in the report of that committee, has been considering, the past year, the development of the research possibilities within the Society and how best to organize them. If you will look over the reports of the various committees in the Society, you will notice that certain of them confine themselves almost exclusively to the framing of specifications and the development of testing methods. We have reorganized Committee E-1 on Methods of Testing, which is doing most excellent work to-day on the question of systematizing and developing our testing methods. Now it has occurred to some of us that a similar committee might be formed to advantage in the Society for the development of research. It would not be expected that such a central or steering committee would itself carry out research, but would look over the Society's activities and seeing the blanks, so to speak, in the research picture as related to materials and engineering and industry, would find men who are willing and adapted to that type of work, and would endeavor to interest them in it. Such investigations as these might readily reveal groups of men interested in the subjects on which many of our committees are now at work, but interested in a different way—not so much in testing and standardization as in the development of further knowledge of these materials. Such groups of men might be formed into individual research committees working in conjunction with existing standing committees. A central or steering committee on research could also take into account the many facilities in various centers, governmental, university and elsewhere.

It seems to your Executive Committee that following out a plan of this kind would be productive of much good. This matter is now

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[1] See pages 59-61.

[2] Director, U. S. Bureau of Standards, Washington, D. C.

The President

before you for discussion. The Executive Committee has not, as yet, come to any final decision in the matter, and they wish to secure the consensus of opinion of those interested.

Mr. Talbot

ARTHUR N. TALBOT.[1]—I have little to say on this matter except to approve what has been stated in the report of the Executive Committee and the statement of President Burgess. One of the features of the Society's work, one of its purposes, is the contribution to the knowledge of Engineering Materials, and I feel certain that this part of the Society's work may be extended with great advantage. In considering certain purposes and needs, such as specifications, important though they are, we are likely to overlook the need for further information, and concerted, organized search for this information. The committees are at work, but, as has been stated by President Burgess, there may be material in the Society which would gladly be set at work, welcoming the opportunity to work on various problems. With an organized effort and with suggestions made from such a committee as is proposed, the membership will willingly work further along certain lines. I am sure that there are facilities in our laboratories in industrial establishments, in universities, and elsewhere, that could well be utilized for this purpose. It seems to me, then, that this project should have the approval of the Society.

Mr. Hatt

W. K. HATT.[2]—Research enjoys a vogue at present, fortunately and rightly. It is believed in almost as a religion, with much lip service. Lips are likely to be tightly closed when the collection plate is passed. The organization of research and research committees proceeds apace, to the extent that the unit of ultimate value in fundamental research, that is, the individual research worker, is encompassed about with so great a cloud of witnesses. The American Society of Civil Engineers, the American Concrete Institute, the Western Society of Engineers have research committees, and also certain governmental departments. There is the National Research Council, the Engineering Foundation, and the research organization of the Association of Land Grant Colleges, which is one of the most powerful of the agencies.

Now, one aspect of science is the simplification and economy of thought, and one aspect of engineering is economy of action. It would be profitable to inquire into the function of any proposed committee before adding to the structure of such committees, in which duplication of effort is less defensible than in the activities of research workers themselves.

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[1] In Charge of Theoretical and Applied Mechanics, University of Illinois.

[2] Director, Advisory Board on Highway Research, National Research Council, Washington, D. C.

Mr. Hatt For, indeed, parallel attacks on any research problems are desirable. It is only necessary that researchers should have a knowledge of mutual progress, and a clearly defined objective placed in its setting in the particular field. It is well, for instance, that the Highway Department of Illinois, the University of Maryland and Purdue University should have attacked the problem of fatigue of concrete independently.

ON RESEARCH IN GENERAL

In academic circles special attainments in two different fields are signalized by two honors—the Phi Beta Kappa and the Sigma Xi; the former in the field of humanities and the latter in scientific research wherein the truth is sought through the study of nature. I do not know how to draw a line between the fields of so-called academic research and so-called industrial or engineering research. Each must advance, if at all, by scientific methods. Considered as a class set apart by their tastes and their aptitudes from the class of producers and constructors, research workers are of a family.

In a recent conversation with a friend whose mental acumen I admire greatly, but whose narrow definition of research I deplore, it seemed to me there might be a need to attempt to describe some of the characteristics of research. I would suppose that the quality of a research worker is a spiritual quality and is not to be measured by specific actions. Therefore there is a danger in attempting to formulate a measure. Certainly there is a clear distinction between the research type of man and the other who has an instinct for controlling others or for production.

My lot has been cast in with those who experiment or perform research in groups; with a program fixed in advance, and an organization to carry it out. Some of the individuals of the group are only required to be painstaking and faithful observers, to be devoted to their task of measurement with precise instruments, whether in the heat of summer's sun or the freezing weather of winter, in confined situations and fatiguing postures. Others have envisaged the problem, organized and secured support for its solution; they may have prepared a working plan, or left that to others.

Some time ago I gathered together from various sources, chiefly from a report of a committee of Sigma Xi, a list of the features of research, as follows:

1. Research work may be in *industrial* fields with a definite aim or in *abstract* science without thought of particular use.
2. The research may lie in the field of any branch of knowledge that is treated in a scientific spirit including, of course, the natural sciences, but not excluding mathematics, history, economics and medicine.

3. The *method* may be by *deduction*, based upon natural phenomena, and always referenced thereto, or by *induction*, using the methods of modern experimental science, both to discover new facts or uncover underlying laws, or the determination of the mechanism by which one event follows another, resulting in a substantial addition to the existing body of knowledge. **Mr. Hatt**

4. The *qualities* by which true research is known are earnestness, devotion, diligence and system, and, in highest form, original and creative work.

5. *Recognition* should be given to skill and initiative in devising suitable methods and apparatus for use in observations, and care and devotion shown in difficult observations, skill in arranging and interpreting data, or forming generalizations upon them.

6. The *result* should be the discovery of something hitherto unknown.

The following are activities and workers not considered:

1. The work of the mere routine worker without initiative or responsibility.
2. The manual operations of the mechanic.
3. The work of the merely critical and negative mind.
4. Purely regulatory functions.
5. Those with only an amateurish and discontinuous interest in research.
6. Those with only the acquisitions of the learned scholar who may have absorbed the results of research.
7. Inventors, unless they are scientists.

Anatole France has well expressed one fundamental quality of the research worker, namely, "Curiosity," in the following quotation:

> "Et je songeai que la grande vertu de l'homme est peut-être la curiosité. Nous voulons savoir; il est vrai que nous ne saurons jamais rien, mais nous aurons du moins opposé au mystere universal qui nous enveloppe une penseé obstineé et des regards audacieux; toutes les raisons des raisonneurs ne nous queriront point, par bonheur de cette grande inquiétude qui nous agite devant l'inconnu."[1]

FUNCTION OF RESEARCH COMMITTEES

In the first place such a committee must deal gently with the individual researcher. He is often temperamental; he instinctively resents a control which will limit his freedom to follow new paths that open up in the progress of his work; he is apprehensive that he will be betrayed into premature publication by those who are charged

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[1] "And I reflected that curiosity is perhaps the greatest virtue of man. We wish to know; true, we shall never know anything, but at least we shall have endeavored to penetrate with persistent questioning and daring scrutiny the universal mystery which envelopes us. Happily not all the arguments of the philosophers will cure us of this inquietude which stirs us in the face of the unknown."

Mr. Hatt with the duty of securing funds to keep the research alive; he guards the product of his research against appropriation by others for unfair credit. Initiative, originality and play of the imagination of the individual investigator must be given free rein.

The personality of the individual researcher should also be guarded in respect to his individual style and expression in reports, and should not be destyled by editors who reduce everything to dull monotony of official forms. The conclusions of a man who has lived through an investigation should not be whittled down by timorous officials.

And yet here arises a practical difficulty, namely, the proper balance between necessary control by an organization and the individual initiative of the research worker, in the case of large projects such as those underlying the art of highway construction where are involved large expenditures; an organization of researchers comprising various degrees of experience, from routine observers and recorders up to those who conceive and plan the researches and who are responsible for the scientific conclusions and the success attending the expenditures of such large funds. There are also individuals whose services are necessary for the orderly progress of the work, considered as a production job.

Projects are begun only after a statement of definite purpose, a working plan, and an appropriation of funds, followed up by an accounting system, not only for expenditures, but from the standpoint of production. The problem here is to provide an effective organization without dampening the initiative of the individual, killing his imagination and destroying that sense of criticism and responsibility which are necessary if large projects in an unknown field are to arrive at useful and significant conclusions.

Where then does a research committee find its field of usefulness when not supplied with funds for operating a specific project? It seems to me that the research committee functions as a staff organization. I have endeavored to define these functions for the research committees of the Advisory Board on Highway Research as follows:

1. The entire purpose of a research committee is to render service to investigators, and to accelerate progress in the attack upon important problems. It avoids any attitude of proprietorship in the researches which form the subject-matter of its deliberations, or of any control or direction of the individual researcher, whose initiative and freedom are necessary conditions of his work. Coordination of research is attempted, inspiration given to those who are at work, and the broad interests of research advanced by reasonable publicity concerning activities. Information of work under way is spread abroad so that seekers after knowledge may know where to find it; communications established between fields of research.

2. Research committees do not formulate standards of methods of test, or approved practices in construction. **Mr. Hatt**

3. Reports of these research committees are not channels for publication of investigations, although a summary of established conclusions from published investigations should appear in the reports to show the status of research.

4. The unique work of the research committees is:

(*a*) To bring together researchers who are working in the same field in order to reach a definition of objectives, and to bring to each researcher a knowledge of the technique and progress of his fellow workers.

(*b*) To assemble, analyze and review the published data of investigations, or the data placed at the disposal of the committees, for the purpose of judging the extent and stability of the research basis for standards, or for the principles and laws underlying the field of the work of these committees.

(*c*) To study needed and profitable research activities.

(*d*) To stimulate competent agencies to perform research in such fields.

(*e*) To prepare working plans for specific researches in cooperation with investigators or for submission to research agencies.

(*f*) To call attention to researches which need financial support, and to recommend a means for securing such support.

(*g*) To publish information of researches under way, and of the tools of research, as instanced in ***Bulletin No. 21***, entitled "A Census of Highway Research Projects in the United States" published by the National Research Council, and ***Bulletin No. 35***, describing apparatus used in highway research.

Of these services the three outstanding are:

1. The coordination of the researchers in connecting fields. For instance, the objective of certain researches by highway engineers must be established only in consideration of the traffic on the road. The automotive engineer and the highway engineer should be brought into conference for a definition of their appropriate fields of work and to lay out programs of research.

2. A committee may render valuable service in surveying the data of research to appraise progress and recommend further work; and also evaluate the application of research work in the industry.

3. A particular field of usefulness is to bring into close relation the laboratory and the field, because very often laboratory men have very meager knowledge of the service of the material, and the requirements fixed by the laboratory may be quite unreal and not appear in the service value of the construction.

If only for internal service in the A.S.T.M., a research committee of this Society would seem to be necessary to perform these duties in the field of materials of construction where areas overlap, and there is so much of technique in common. Furthermore, the critical scrutiny by competent persons of the fundamental data of research underlying the work of any committee would serve to postpone premature standardization and would indicate necessary additional

Mr. Hatt experimentation. I venture also to suggest that the work of such a research committee would prevent, or at least diminish, the tendency observed on the part of officials of the State Highway Commissions to go their own way in the establishment of specifications for materials that must meet the local needs and conditions of the widely varying regions of the United States.

It is not sufficient for such research committees to set themselves at a table at scattered intervals without a large amount of preparatory work. A research committee needs analysts to prepare the data of research for scrutiny, not only published researches, but those which are complete or nearly so and have not reached channels of publication. The committee is not averaging opinions but rendering judgment upon complete evidence. It is only an illusion to suppose that a research committee can be useful without adequate financial support. Its value is expressed in terms of activity and not in an imposing roster of distinguished names.

The necessity of research before standardization has been well expressed by Mr. A. A. Stevenson, past-chairman of the American Engineering Standards Committee. To take an example: The standardization of colors for signals for highway traffic demands agreements as to conventions by a standardization committee. But underlying this agreement must be research upon the optical and psychological elements of the situation, to be cared for by a research committee. Otherwise the agreements may violate fundamental human reactions.

Mr. Corse MR. W. M. CORSE.[1]—Mr. Talbot and Mr. Hatt have mentioned the National Research Council, assuming that everybody in the room knew what it is, how it was organized and how it would help in a matter of this kind. I find that a good many people are somewhat hazy as to what the National Research Council is, and I trust that those of us who know will excuse me if I repeat what I have found some people do not quite fully understand. The National Research Council was organized in 1916 to help the Government on scientific work. At that time it was a governmental institution, organized under the charter of the National Academy of Sciences, but at the present time it is not connected with the Government at all. It is financed by a $5,000,000 grant from the Carnegie Corporation of New York, of which $1,350,000 is being spent on a building and the equipment for it in Washington. The income of the remainder is used for organization expense and cannot, according to the grant, be used for specific researches. Many people think that the Council

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[1] Chairman, Division of Research Extension, National Research Council, Washington, D. C.

Mr. Corse

conducts a laboratory and that it therefore comes into competition with other research laboratories, but this is not so: the money is spent for coordinating researches and to help start researches that otherwise might not get started. A few hundred dollars often starts a research activity, and then the interest is sufficient to keep it moving. The Council is glad to cooperate with any committee such as has been suggested here, and I hope that we may be called upon to aid in any work that this Society suggests.

In order to let you know some of the things that we have been doing so that you may see how you may use us best, I should like to tell you of a few things that have been done in the past two or three years. We have had allocated to us, to be spent on various research problems in the last three years, approximately $2,500,000. That is entirely aside from the income that pays our office rent, expenses and salaries; it is spent entirely on research. The Engineering Division, with which Mr. Hatt is connected, has had the expenditure of a relatively large amount of money, some of the largest amounts being spent on his own particular problem, namely, the Highway Research; but the largest single item in this $2,500,000 has been $1,325,000 from the Rockefeller Foundation for fellowships. This sum is to be spent during the next five years for fellowships in universities for medicine, for physics and chemistry, and for biology. These fellowships are given only to men who have already received a Doctor's degree. The Council sets up the machinery to administer this money; it surveys the field to find out the best men to have the fellowships, and acts as the organizing arm for the Rockefeller Foundation. As an example of what this may lead to, when Doctor Rosenhain of the National Physical Laboratory of Great Britain was in this country this spring, I was talking to him about these fellowships and the amount of money that we were proposing to spend on them, and he gave me an example which I think, if it can be duplicated in this country, will make this expenditure well worth while. In Great Britain in 1851 there was a large exposition. The profits of that exposition were invested, and the interest from this investment is used for fellowship funds. He tells me that the best scientific men in Great Britain to-day are what is known as 1851 scholars; that is, they benefited by the income from this fund that I have just mentioned. Now, if we can develop in this country through those fellowships the type of men they have developed in England from this 1851 fund, I think that this money will be well spent.

One of the things that I think should be mentioned and which this proposed research committee might make use of, is the contact

Mr. Corse with men of pure science that can be obtained through the various scientific divisions of the Council. The Engineering Division of the Council is the only industrial technological division that we have. The other divisions, six of the seven, are divisions of pure science, and when you get into research problems, you often want to refer to pure science. Frequently, if you are in the engineering field, you do not know the best man to consult on a particular problem. I believe we are in a position to help you in that way, probably more than any other agency, because we are organized to do that very thing.

Another thing I should like to mention is the preparation of so-called international critical tables of chemical, physical and technological data. President Burgess mentioned it in his Address last evening and showed us the importance of this work. He mentioned the annual tables prepared by Professor Marie of France, and mentioned the desirability of further work in this connection. The National Research Council has been asked to prepare a set of tables of critically evaluated data, which will be probably about two volumes of a thousand pages each. Those of us who have occasion to use Langdolt and Bernstein know that this book is not up to date and does not have the most recent information in it. More than that, it is in German and our young men coming from universities to-day are not as familiar with the German language as they were a few years ago; consequently, it seems very important that we have a book of this kind in English. We consider it one of the most important projects that we have ever had presented to the National Research Council.

In conclusion I wish to say that I hope the Society will appoint a Committee on Research, and I am pleased to express on behalf of the National Research Council our desire to be of all possible assistance.

Mr. Schmitt MR. F. E. SCHMITT.[1]—Observation of the Society's meetings for quite a number of years past leads me to welcome the decision to stimulate research. It will develop a very powerful resource that now lies dormant in the Society. The remarkable possibilities of the membership and its affiliations in the direction of creating new knowledge of materials have not been fully utilized heretofore.

There is a very natural reason for this failure: the Society has been fully occupied with the busy and necessary work of developing specifications. The need for such work, in fact, was the motive for the initial departure of the American organization from the international organization twenty-five years ago. It was therefore

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[1] *Engineering News-Record*, New York City.

Mr. Schmitt

inevitable that we should pay less attention to methods of testing and to knowledge of materials.

In the attempt to broaden from the narrow purpose of the Society's early days, methods of testing have already been taken up, through the reorganized Committee E-1 that has been at work during the past two years. If we now will put the same force of purpose and the same directed intent into the development of additional and better knowledge, we will round out the scope of our labors most excellently. Some years ago Past-President Capp with remarkable foresight pointed to the neglected field of knowledge of materials and urged that the Society enter it. The succeeding administrations have followed out his suggestion, and I presume President Burgess has the credit of bringing about the definite action now taken.

As to the form which the work should take, there may be difference of opinion. To what extent research can be guided or organized, how effectively it can be handled by a governing committee, is rather doubtful. But in any event the methods will need to be worked out, and the Executive Committee can safely be trusted to work them out soundly and efficiently.

The Society has already done a great deal of research work. But heretofore that research has been tied to the bread-and-butter work of preparing specifications, and has, I think, been hampered and limited thereby. Research is sufficiently intangible that its methods and the spirit that guides it are not susceptible of ready definition. I have not had a chance to think over Mr. Hatt's analysis of research, but my own conviction has been that a committee can check or hamper research more than stimulate it.

Our ideal purpose is expressed in the presidential address of yesterday that we should "develop the latent possibilities for organized research which exist within the membership, the committees and the affiliations of the Society." Doctor Burgess, however, said, "organized research," and there is some question of the propriety of that word "organized." The stimulation of the research spirit should ultimately reach the individual members and individual laboratories, and I believe that the entire scheme of "organization" devised for that purpose should be made subservient to the purpose of reaching the individual and getting him to try to find out new things.

REPORT OF COMMITTEE A-1
ON
STEEL

During the past year Committee A-1 has held two meetings, one on October 5, 1922, and the second on March 9, 1923. A third meeting will be held prior to the presentation of this report to the Society, at which the report will be briefly reviewed and other matters considered.

The Advisory Committee has held two meetings, at which matters concerning the general administrative affairs of the committee were considered.

The present membership of the committee is 144, of which 79 are classed as non-producers and 65 as producers.

Sub-Committees.—Two new sub-committees have been appointed during the year: Sub-Committee XX on Plate Tolerances, and Sub-Committee XXI on Steel for Welding.

Recommendations Affecting Standards and Tentative Standards

The recommendations of the committee affecting standards and tentative standards are presented first in summarized form together with an analysis of the letter ballot on each item. They are then referred to where necessary in greater detail, being grouped for convenience in the order of the respective sub-committees directly responsible for them.

I. Proposed Revisions in Standards.—The committee recommends that the revisions in the following standards, which are given in full in Appendix I to this report, be published as tentative for one year before referring them to letter ballot of the Society for adoption as standard:

1. For Open-Hearth Steel Girder and High Tee Rails (A 2 – 21).
2. For Structural Nickel Steel (A 8 – 21).
3. For Structural Steel for Locomotives (A 10 – 21).
4. For Structural Steel for Cars (A 11 – 21).
5. For Steel Castings (A 27 – 21).
6. For Welded and Seamless Steel Pipe (A 53 – 21).
7. For Boiler and Firebox Steel for Locomotives (A 30 – 21).
8. For Boiler Rivet Steel (A 31 – 21).

II. Proposed Revisions in Tentative Standards.—The committee recommends that the revisions in the following tentative specifications, which are given in full in Appendix I to this report, be approved, and that the specifications as thus revised be continued as tentative for another year:

9. For Boiler and Firebox Steel for Stationary Service (A 70 – 21 T).
10. For Steel Plates for Forge Welding (A 78 – 21 T).

III. Proposed New Tentative Standard.—The committee recommends that the following new specifications, which are appended to this report,[1] be accepted for publication as tentative:

11. For Steel Plates of Flange Quality for Forge Welding.

IV. Tentative Standards.—The committee recommends that the following tentative standards remain as tentative for another year:

For Steel Tie Plates (A 67 – 20 T).
For Carbon Tool Steel (A 71 – 21 T).
For Low-Carbon-Steel Track Bolts (A 76 – 20 T).
For Electric Cast-Steel Anchor Chain (A 77 – 20 T).
For Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 21 T).
For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 22 T).
For Carbon-Steel Castings for Railroads (A 87 – 22 T).

The above recommendations have been referred to letter ballot of the committee, which consists of 144 members: .. ballots have been cast, .. members having refrained from voting. The analysis of the vote of the committee is given in the following table:

Items	Affirmative	Negative	Not Voting[a]
I. Proposed Revisions in Standards			
1. For Open-Hearth Steel Girder and High Tee Rails (A 2 – 21)	64	0	62
2. For Structural Nickel Steel (A 8 – 21)	76	0	50
3. For Structural Steel for Locomotives (A 10 – 21)	78	1	47
4. For Structural Steel for Cars (A 11 – 21)	79	1	46
5. For Steel Castings (A 27 – 21)	83	6	37
6. For Welded and Seamless Steel Pipe (A 53 – 21)	72	4	50
7. For Boiler and Firebox Steel for Locomotives (A 30 – 21)	74	2	50
8. For Boiler Rivet Steel (A 31 – 21)	72	4	50
II. Proposed Revisions in Tentative Standards			
9. For Boiler and Firebox Steel for Stationary Service (A 70 – 21 T)	76	2	48
10. For Steel Plates for Forge Welding (A 78 – 21 T)	73	2	51
III. Proposed New Tentative Standard			
11. For Steel Plates of Flange Quality for Forge Welding	76	2	48

Total number of ballots cast	126
Number of members who failed to vote	18
Total membership	144

[a] In this column are recorded the number of votes cast as "Not Voting" on the various items.

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[1] See p. 551.—Ed.

In the following the committee presents the foregoing recommendations in detail where necessary, as well as other features of its work, grouped for convenience in the order of the respective sub-committees responsible for them.

SUB-COMMITTEE I ON STEEL RAILS AND ACCESSORIES

This sub-committee is recommending a revision of certain sections of the Standard Specifications for Open-Hearth Steel Girder and High Tee Rails (A 2 – 21), which will bring them into agreement with the specifications adopted by the American Electric Railway Engineering Association. It is also recommending that the serial designation of the Standard Specifications for Carbon Steel Rails (A 1 – 14)[1] be changed to A 1 – 21, for the reason that in 1921 the specifications were extensively revised as to form, and at the same time the sections covering the nick-and-break test were reworded to clarify the meaning.

SUB-COMMITTEE II ON STRUCTURAL STEEL FOR BRIDGES, BUILDINGS AND ROLLING STOCK

This sub-committee is recommending the insertion of requirements for minimum elongation in 2 in. in the Standard Specifications for Structural Nickel Steel (A 8 – 21), Structural Steel for Locomotives (A 10 – 21) and Structural Steel for Cars (A 11 – 21). A sub-sub-committee has also been appointed to review the specifications and recommend such change in wording as may be necessary to clarify the meaning of those sections covering the permissible use of the 2-in. gage length test specimen.

SUB-COMMITTEE VIII ON STEEL CASTINGS

This sub-committee is recommending a complete revision of the Standard Specifications for Steel Castings (A 27 – 21) in which two classes of castings are provided for, as in the present specifications: Class A with chemical analysis only, and Class B having both chemical and physical properties specified. Reference to patterns has been eliminated as being unnecessary in a material specification. In the chemical requirements no change has been made in Class B castings, but the carbon for Class A has been raised from 0.30 to 0.45 per cent, maximum, in order to bring this in agreement with current practice. No change has been made in the tensile strength or yield point requirements for the three grades of Class B castings, but the ductility requirements for elongation and reduction of area have been raised in all three grades in order to bring these into line with the results now being obtained by modern practices. Reference to special requirements for castings for railway rolling stock have been eliminated since these are now covered by Specifications for Carbon-Steel Castings for Railroads: A 87 – 22 T. The use of the term "annealing" has been dropped and "heat-treatment" substituted, with the requirement that "Heat treatment shall be in accordance with the Tentative Recommended Practice for Heat Treatment of Carbon-Steel Castings (Serial Designation: A 36–22 T) of the American Society for Testing Materials, unless otherwise specified by the purchaser." These are the principal differences from the present specifications. Other changes consist in re-wording of certain sections in order to clarify the meaning. This revision represents the result of very careful consideration on the part of the sub-committee which has endeavored to cover all the points raised by manufacturers and consumers, having in mind that Specifications A 27 are intended to cover all castings intended for a very wide variety of purposes and cannot, therefore, be as restrictive in its requirements as the Specifications for Carbon-Steel Castings for Railroads (A 87 – 22 T).

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[1] 1921 Book of A.S.T.M. Standards.

SUB-COMMITTEE IX ON STEEL TUBING AND PIPE

Sub-Committee IX is recommending a change in the phosphorus requirement for lap-welded pipe in the Standard Specifications for Welded and Seamless Steel Pipe (A 53 – 21). The committee also has before it consideration of the preparation of Specifications for Tubular Goods for Oil Country Use and has a sub-sub-committee actively engaged on these specifications.

SUB-COMMITTEE XI ON BOILER STEEL

This sub-committee has been cooperating with the Conference Committee appointed by the Society to work with the A.S.M.E. Boiler Code Committee and as a result is recommending certain revisions in the Standard Specifications for Boiler and Firebox Steel for Locomotives (A 30 – 21), the Standard Specifications for Boiler Rivet Steel (A 31 – 21), and in the Tentative Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 21 T). A sub-sub-committee has been appointed to consider the preparation of tolerances for finished rivets. The proposed changes as affecting firebox steel are intended to differentiate between firebox and flange steel by calling for slightly higher elongation in the firebox class. The removal of the lower carbon limit for firebox steel is recommended because it is considered an unnecessarily close restriction in view of the fact that both lower and upper limits are specified for tensile strength.

The following abstract of a report of a Sub-Sub-Committee on Homogeneity Tests is given below for the information of the members:

REPORT OF SUB-SUB-COMMITTEE ON HOMOGENEITY TESTS

MR. E. J. EDWARDS,
Chairman, Sub-Committee XI.

Dear Sir:

This sub-committee had been instructed to consider the question of the advisability of including in the specifications for firebox steel a homogeneity nick-and-break test of a transverse specimen taken from the middle of the top of firebox plates in addition to the homogeneity test now required from a longitudinal test specimen taken from the bottom edge of the plate.

Not a very large amount of data is available for transverse homogeneity tests but some mills have records of the usual longitudinal tests that support the conclusions regarding the prevalence of small laminations throughout boiler plate. The following table gives a summary of the results obtained in the tests made by your sub-committee:

Source of Firebox Plates	Total Number of Tests		Number of Specimens with Laminations over $\frac{1}{4}$ in.		Number of Laminations of a Given Length												
	Transverse	Longitudinal	Transverse	Longitudinal	Method of Taking Specimens[1]	$\frac{1}{4}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.	$\frac{7}{16}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.	$1\frac{7}{8}$ in.	$1\frac{1}{4}$ in.
Baldwin Locomotive Works, New Plates	110	393	21	63	T	8	...	10	...	3	2	1	...	4	1	...
					L	(Not recorded in detail)										
Pennsylvania Railroad, New Plates	38	37	10	18	T	7	3	...	3	3	1	...	...	...	...	...
					L	16	5	10	...	2	1	...	...	...	...	...
Old Locomotive, built 1887	12	12	5	7	T	5	...	3	...	1	1	...	...	...	...	...
					L	1	...	4	...	1	1	1	...	...	...	...
Old Stationary Boiler, built 1893	10	5	37	13	T	14	7	2	4	9	7	4	...	1	1	2
					L	9	...	2	3	4	3	1	...	...	...	...

[1] "T" indicates transverese: "L", longitudinal.

NOTE.—Nearly all tests, both transverse and longitudinal, show a number of laminations below $\frac{1}{4}$ in. in length.

The investigation made on the old firebox plates which had been long in service shows them to contain many laminations which would have caused rejection if found in a test specimen. Some new plates taken from accepted stock also show laminations due to unwelded gas bubbles throughout the sheets. So far as this sub-committee has been able to go into the subject it appears that this laminated condition is characteristic of this grade of steel and possibly every sheet made contains more or less laminations which would cause rejection if appearing exactly at the spot where the nick-and-break test is made. The more nick-and-break tests made, the greater the chance of finding the laminations and rejecting the sheet. Judging from the old firebox sheets examined, these small laminations do not appear to have any detrimental effect on the life of the sheets. The large amount of punching which is done on firebox sheets gives opportunity for finding laminations or overlaps in the metal (which may cause blistering of the sheets in service) and it is customary to reject sheets showing such defects when punched.

Your sub-committee is of the opinion that the present homogeneity test is of questionable value and recommends that no additional homogeneity test be made on transverse specimens from the top of the sheets. Such an additional test might increase the number of sheets rejected, if the laminations happened to occur where the test is made, but would not be an indication of any better quality in the sheets that were accepted.

It is recommended that Sub-Committee XI give consideration to the broader subject of improving the quality of firebox steel by such changes in the process of manufacture as may be necessary to secure freedom from occluded gases and consequent laminations in the finished sheets.

Respectfully submitted on behalf of the sub-sub-committee,

W. G. HUMPTON,
R. P. JOHNSON,
F. M. WARING.

SUB-COMMITTEE XII ON METHODS OF CHEMICAL ANALYSIS

The ladle test ingot investigation on which preliminary reports were made in 1916 and 1919, was completed last year, and the final report with conclusions is presented in full in Appendix II.

SUB-COMMITTEE XIII ON METHODS OF PHYSICAL TESTS

This sub-committee is keeping in touch with the work of Committee E-1 on Methods of Testing, through its chairman, Mr. T. D. Lynch, who represents Committee A-1, and all matters affecting methods of testing in specifications under the control of Committee A-1 will be given consideration and submitted to Committee A-1 for decision.

SUB-COMMITTEE XV ON COMMERCIAL BAR STEELS

This sub-committee considered the question of the preparation of specifications for cold-finished shafting and as a result found that this was largely a question of tolerances on the size of shafting and came to the conclusion that such a subject could best be handled by the Sectional Committee on Standardization of Shafting which has been organized under the American Engineering Standards Committee. It was also thought that due to the variety of methods of manufacture of cold-finished shafting it would be extremely difficult, if not impossible, to provide for physical characteristics of the material; consequently, this sub-committee reported to Committee A-1 that in its opinion it was inadvisable to prepare specifications for shafting providing for physical characteristics of the material and tolerances. This report was approved by Committee A-1.

At the request of the Executive Committee, Committee A-1 has appointed as its representatives Messrs. J. J. Shuman and F. M. Waring to keep in touch with the Sectional Committee on Standardization of Shafting of the American Society of Mechanical Engineers, the intention being to cooperate in every way possible with the development of this subject and to ascertain definitely whether it will be advisable or possible to write specifications for shafting.

SUB-COMMITTEE XX ON PLATE TOLERANCES

During 1921 a joint committee consisting of representatives of Sub-Committees II, III and XI did a large amount of work in the endeavor to harmonize opinions and data concerning the proper interpretations and use of the tables of tolerances for plates now appearing in our specifications. As a result of this investigation Committee A-1 in 1922, had certain recommendations to make regarding the limiting of the present tables of tolerances on plates to those of rectangular shape, and in the case of boiler steel to limit the last column of the table of tolerances to plates 132 to 144 in. wide, exclusive. These proposed changes were not satisfactory to a great many members of the committee, and after considerable discussion at the June, 1922, meeting it was decided to withdraw all recommendations affecting plate tolerances and to put this subject into the hands of a special sub-committee to be known as Sub-Committee XX on Plate Tolerances.

This new sub-committee has effected an organization with Mr. A. A. Stevenson, chairman, and is at work on the subject of rolling tolerances for plates. It has appointed two sub-sub-committees: one to look into the situation and collect data on plates up to 144 in. in width, and the second to consider the situation and collect data towards the establishment of a table of overweight tolerances for plates 144 in. and over.

SUB-COMMITTEE XXI ON STEEL FOR WELDING

A new sub-committee on steel for welding, has been organized under the chairmanship of Mr. F. N. Speller. It is an outgrowth of the work started by Sub-Committee II which originally prepared the Specifications for Steel Plates for Forge Welding (A 78 - 21 T). In view of the special nature of this subject, Committee A-1 decided to place it in the hands of a separate sub-committee. The work has been actively pursued during the past year and the sub-committee has reported proposed revisions of Specifications A 78 - 21 T to cover

Steel Plates of Structural Quality for Forge Welding, and has submitted new Tentative Specifications for Steel Plates of Flange Quality for Forge Welding.[1]

This report has been submitted to letter ballot of the committee, which consists of 144 members, of whom 95 have voted affirmatively, 2 negatively, and 47 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. WARING,
Chairman.

G. H. WOODROFFE,
Secretary.

EDITORIAL NOTE

The proposed revisions of the 7 standard specifications listed in this report as items 1 to 4 and 6 to 8 on page 80 were accepted for publication as tentative and appear on pages 951 to 955. The proposed revisions of the Standard Specifications for Steel Castings, with the modification given in the Summary of the Proceedings, page 20, were accepted for publication as new tentative specifications and appear on page 555.

The proposed Tentative Specifications for Steel Plates of Flange Quality for Forge Welding were accepted for publication as tentative and appear on page 551.

The proposed revisions of the Tentative Specifications for Boiler and Firebox Steel for Stationary Service; and for Steel Plates for Forge Welding referred to in this report were accepted. The specifications as thus revised appear on pages 541 and 546, respectively.

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[1] See p. 551.—ED.

APPENDIX I

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this appendix are given proposed revisions in certain standard and tentative specifications, which, for convenience, are numbered from 1 to 10, inclusive, to correspond to the report of the committee. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

PROPOSED REVISIONS IN STANDARDS

No. 1.—Standard Specifications for Open-Hearth Girder and High Tee Rails: A 2 - 21.[1]

Section 7 (*b*).—Change to read as follows by the addition of the italicized words:

"Excess scale on the head *or web* of the section shall be carefully removed."

Section 8.—Change from its present form: namely,

"(*a*) The head of each specimen shall be subjected to a pressure of 50 net tons (100,000 lb.) for a period of 15 seconds, applied through a ball ¾ in. in diameter.

"(*b*) The average depth of impression obtained on the four specimens shall not be more than 3.8 mm. for Class A rails, nor more than 3.6 mm. for Class B rails."

to read as follows:

"(*a*) *Impression Test.*—The head of each specimen shall be subjected to a pressure of 100,000 lb. (45,359 kg.) net for a period of 15 seconds applied through a hardened steel ball 0.75 in. (19.05 mm.) in diameter.

"(*b*) *Test Balls.*—The steel test ball shall have a minimum Brinell hardness of 600 and it shall not be possible to attack the surface of the ball with an American Swiss Pillar File No. 2.

"(*c*) *Permissible Variation in Test Balls.*—When fractured, the ball shall show a fine uniform grain, with no indications of overheat or underheat and the fracture shall resist file attack for at least one-third of its depth from the surface of the ball. The permissible variation in the diameter of the ball shall not be greater than 0.002 in. over or under the standard size, and the permanent deformation under the required loading shall not be over 0.003 in.

"(*d*) *Depths of Impressions.*—The average depth of impression obtained on the four specimens shall not be more than 0.1496 in. (3.8 mm.) for Class A rails, nor more than 0.1471 in. (3.6 mm.) for Class B rails."

Section 9.—Change the reference from Section 8 (*b*) to Section 8 (*d*).

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[1] 1921 Book of A.S.T.M. Standards.

Section 12 (a).—Change the reference from Section 11 to Section 10.

Section 15.—Change from its present form: namely,

> "The ends shall be milled square laterally and vertically, but the base may be undercut $\frac{1}{32}$ in."

to read as follows:

> "The ends shall be milled square laterally. They shall be undercut vertically not less than $\frac{1}{32}$ in. and not over $\frac{3}{32}$ in."

Section 18 (a).—Change the reference from Section 11 to Section 10.

NO. 2.—STANDARD SPECIFICATIONS FOR STRUCTURAL NICKEL STEEL: A 8 - 21.[1]

Section 6 (a).—In the table on tensile requirements, insert the requirement of 18 per cent for the minimum elongation in 2 in. for shapes, plates, and bars.

NO. 3.—STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR LOCOMOTIVES: A 10 - 21.[1]

Section 6 (a).—Insert the following requirement:

> "Elongation in 2 in., min., per cent........................ 22"

NO. 4.—STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR CARS: A 11 - 21.[1]

Section 6 (a).—In the table on tensile requirements, insert the requirement of 22 per cent for the minimum elongation in 2 in. for structural steel.

NO. 5.—STANDARD SPECIFICATIONS FOR STEEL CASTINGS: A 27 - 21.[1]

These specifications have been extensively revised and are appended hereto[2] in their revised form as proposed tentative standards.

NO. 6.—STANDARD SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE: A 53 - 21.[1]

Section 3.—Change to read as follows by the addition of the italicized words and figures:

> "Open-hearth steel shall conform to the following requirements as to chemical composition:

	Lap-Welded	*Seamless*
Phosphorus, per cent.............	*not over 0.06*	not over 0.05"

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 555.—ED.

NO. 7.—STANDARD SPECIFICATIONS FOR BOILER AND FIREBOX STEEL FOR LOCOMOTIVES: A 30 - 21.[1]

Section 3.—In the table on chemical requirements, change the requirements for carbon to read as follows by the addition of the italicized words, and the omission of the figures in brackets:

		FIREBOX
Carbon	for plates ¾ in. or under in thickness....	[0.12–] *not over* 0.25 per cent
	for plates over ¾ in. in thickness.......	[0.12–] *not over* 0.30 per cent

Section 6 (a).—In the table on tensile requirements, change the requirement for minimum elongation in 8 in. for firebox steel from $\frac{1\,500\,000}{\text{Tens. str.}}$ to $\frac{1\,550\,000}{\text{Tens. str.}}$

Section 14 (a).—Change from its present form: namely,

> "(*a*) The name or brand of the manufacturer, melt or slab number, class, and lowest tensile strength for its class specified in Section 6 (*a*), shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen."

to read as follows:

> "The name or brand of the manufacturer, the manufacturer's test identification number, class and lowest tensile strength specified shall be legibly stamped on each finished plate in two places not less than 12 in. from the edges and on each butt strap near the center line not less than 12 in. from each end. The manufacturer's test identification number shall be legibly stamped on each test specimen."

NO. 8.—STANDARD SPECIFICATIONS FOR BOILER RIVET STEEL: A 31 - 21.[1]

Section 9.—Change from its present form: namely,

> "The diameter of each bar shall not vary more than 0.01 in. from that specified."

to read as follows:

> "The diameter of hot-finished rivet bars shall not vary from that specified by more than the amount given in the following table:

DIAMETERS, IN.	VARIATIONS IN DIAMETER, IN. UNDER	VARIATIONS IN DIAMETER, IN. OVER	OUT OF ROUND, IN.
Up to ½, inclusive..............................	0.007	0.007	0.010
Over ½ to 1, inclusive.........................	0.010	0.010	0.013
Over 1 to 1¼, inclusive.......................	0.012	0.012	0.016
Over 1¼ to 1½, inclusive......................	0.015	0.015	0.021
Over 1½ to 2, inclusive.......................	0.022	0.022	0.023

Section 10.—Omit this section, reading as follows, re-numbering the subsequent sections accordingly:

> "The finished bars shall be circular within 0.01 in."

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[1] 1921 Book of A.S.T.M. Standards.

Section 16.—Omit this section, reading as follows, re-numbering the subsequent sections accordingly:

"The rivets, when tested, shall conform to the requirements as to tensile properties specified in Section 5, except that the elongation shall be measured on a gage length not less than four times the diameter of the rivet."

Section 19 (a).—Omit this paragraph, reading as follows:

"(*a*) When specified, one tension test shall be made from each size in each lot of rivets offered for inspection."

Section 20.—Change from its present form: namely,

"The rivets shall be true to form, concentric, and shall be made in a workmanlike manner."

to read as follows:

"The rivets shall be true to form and concentric, shall be made in a workmanlike manner, and shall be free from injurious defects."

Section 21.—Omit this section, reading as follows, re-numbering the subsequent sections accordingly:

"The finished rivets shall be free from injurious defects."

PROPOSED REVISIONS IN TENTATIVE STANDARDS

NO. 9.—TENTATIVE SPECIFICATIONS FOR BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE: A 70 - 21 T.[1]

Section 3.—Make the same change as in Section 3 of Specifications A 30 - 21 above.

Section 6 (a).—Make the same change as in Section 6 (*a*) of Specifications A 30 - 21 above.

Section 6 (b).—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

"(*b*) Should the above rule for minimum allowable elongation give a value of less than [24] *25* per cent for firebox steel, the minimum allowable elongation shall be [24] *25* per cent, subject to the modifications of Section 7."

Section 14 (a).—Make the same change as in Section 14 (*a*) of Specifications A 30 - 21 above.

NO. 10.—TENTATIVE SPECIFICATIONS FOR STEEL PLATES FOR FORGE WELDING: A 78 - 21 T.[2]

These specifications have been extensively revised and are appended hereto[3] in their revised form.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 447 (1921).

[2] *Ibid.*, p. 454.

[3] See p. 546.—ED.

APPENDIX II

REPORT ON LADLE TEST INGOT INVESTIGATION

Sub-Committee XII on Methods of Chemical Analysis presents to Committee A-1 the following report describing the work which has been done to supplement that presented in two previous reports on the subject of ladle test ingot investigation.[1]

REPORT BY J. R. CAIN,[2] H. A. BRIGHT,[3] AND G. E. F. LUNDELL[4]

The first report on the subject presented the findings of a chemical and metallographic survey of a considerable number of ingots furnished by various manufacturers These ingots were poured according to the regular practice of the various manufacturers and none were aluminum treated. A considerable number of cases of segregation of carbon and sulfur and unsound ingots were noted. However, no one shape or size was found to be the worst in this respect. A program of further work to decide, if possible, upon the best shapes and sizes of ingots, was suggested by the committee. A part of this program was completed and reported on in the second report of the sub-committee, presented in 1919. In this latter report are set forth the findings of a study made on a low-carbon and medium-carbon series of ingots poured in five types of molds, one set with aluminum and the other in the usual manner. Though this investigation seemed to warrant certain conclusions regarding the influence of aluminum treatment, it was felt that the tests were somewhat limited and not sufficiently comprehensive to make final recommendations. Accordingly, a program was drawn up covering a scope of work sufficient to warrant final conclusions on the ladle test molds and the effect of aluminum treatment. The present report covers this work.

PREPARATION OF THE INGOTS

Test ingots were furnished by a number of cooperating steel companies and were prepared as follows: Each company furnished two sets of ingots from selected heats, one set treated with aluminum as directed, and the other poured as usual, the customary practice and molds of the company being used in each case. The companies were asked to drill and analyze these two sets of ingots according to their usual practice and, after drilling for analyses, to split on the medial vertical plane all the test ingots prepared for the investigation.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XVI, Part I, p. 129 (1916). *Proceedings*, Am. Soc. Testing Mats., Vol. XIX, Part I, p. 154 (1919).

[2] Research Associate, U. S. Bureau of Standards, Washington, D. C.

[3] Associate Chemist, U. S. Bureau of Standards, Washington, D. C.

[4] Chemist, U. S. Bureau of Standards, Washington, D. C.

It was desired to have five sets of ingots of either basic or acid open-hearth straight carbon steel of the following four carbon ranges: 0.15 to 0.30 per cent; 0.30 to 0.50 per cent; 0.50 to 0.80 per cent; and 0.80 to 1.10 per cent. The aluminum treated ingots were prepared by adding aluminum in the proportions of 2 g. per 5 lb. of metal, the aluminum being added as sheet or wire placed in the bottom of the mold before pouring the test ingot.

The split ingots together with the work's analyses were sent to the U. S. Bureau of Standards for further study. The ingots, received from the seven cooperating steel companies, represented 112 heats, each heat having two test ingots, one with, and the other without aluminum treatment. Roman numerals I to VII have been used to designate the ingots from the various companies.

CHEMICAL STUDY OF SEGREGATION

For the segregation study of the two types of ingots, drillings were taken wherever possible at three different positions on each ingot. The position of these drill holes can be noted in Figs. 1 to 6. Drill holes were located when possible at three varying points, unsymmetrical with respect to the ingot. The chemical analyses were distributed among different laboratories. Carbon determinations were made at the U. S. Bureau of Standards by Messrs. Fedde and Larrabee; phosphorus determinations were made by Messrs. Gibboney, Brady and Hosmer; and sulfur was determined by Mr. Hopkins. The A.S.T.M.[1] Evolution Method for sulfur, Alkalimetric Method for phosphorus, and Direct Combustion Method with Absorption in Ascarite for carbon, were used respectively for these elements.

No chemical studies were made at this time on ingots from companies VI and VII. The ingots of both these companies are rather small and present difficulties in securing sufficient sample from definite locations for segregation studies.

While all the ingots were photographed, it was deemed unnecessary to include the complete sets of photographs in this report.[2] A few typical photographs are shown in Figs. 1 to 6 which clearly illustrate the advantage of treating ladle test ingots with aluminum. The tabulated analyses of the segregation survey are given in Table III.

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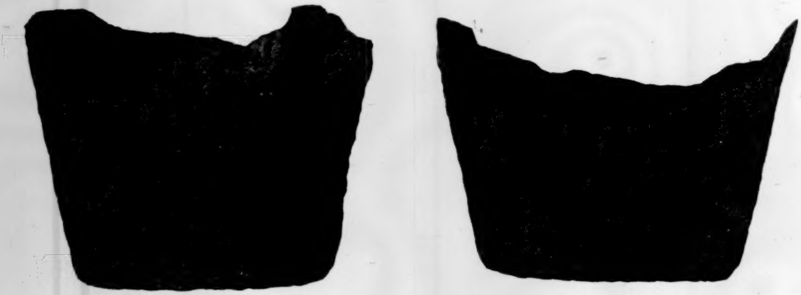
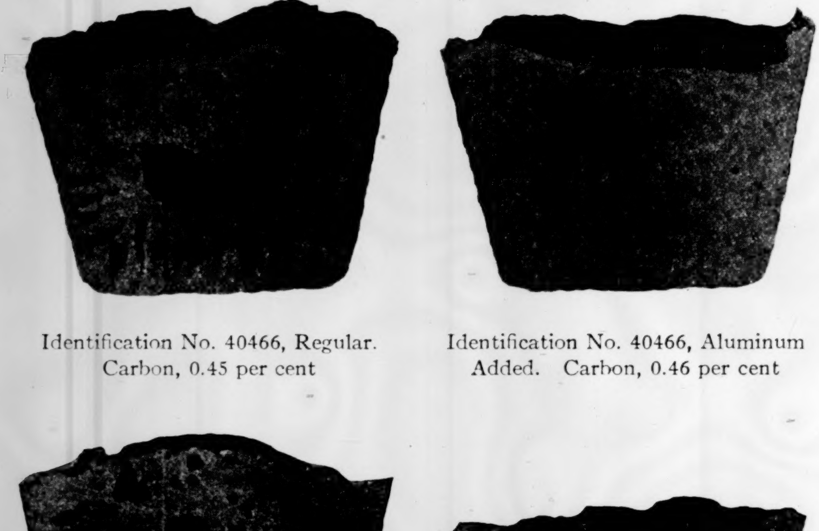
[1] Tentative Methods of Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33 - 22 T) of the American Society for Testing Materials, *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 578 (1922).

[2] A complete set of photographs of the split ingots is on file at the Society headquarters, 1315 Spruce St., Philadelphia, Pa., and may be examined by anyone interested in inspecting them.



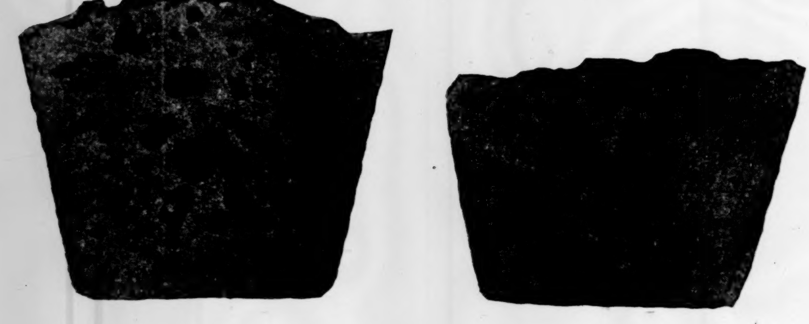
Identification No. 39540, Regular. Carbon, 0.12 per cent

Identification No. 39540, Aluminum Added. Carbon, 0.13 per cent



Identification No. 40466, Regular. Carbon, 0.45 per cent

Identification No. 40466, Aluminum Added. Carbon, 0.46 per cent



Identification No. 45574, Regular. Carbon, 0.96 per cent

Identification No. 45574, Aluminum Added. Carbon, 1.01 per cent

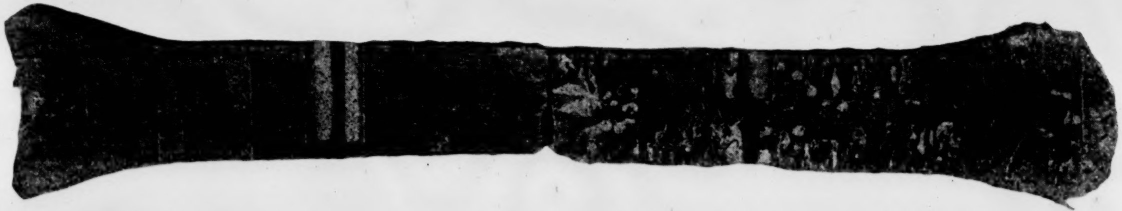
FIG. 1.—Ladle Test Ingots from Company I

Identification No. 18044, Aluminum Added. Carbon, 0.24 per cent

Identification No. 18044, Regular. Carbon, 0.23 per cent

Identification No. 24038, Aluminum Added. Carbon, 0.48 per cent

Identification No. 24038, Regular. Carbon, 0.48 per cent

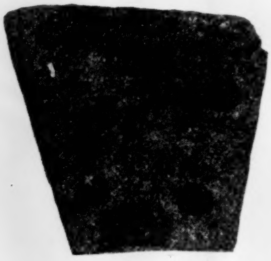


Identification No. 21150, Aluminum Added. Carbon, 0.81 per cent

Identification No. 21150, Regular. Carbon, 0.81 per cent

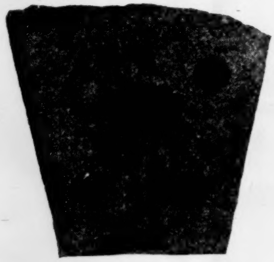
FIG. 2.—Ladle Test Ingots from Company II

Identification No. 16827, Regular.
Carbon, 0.18 per cent

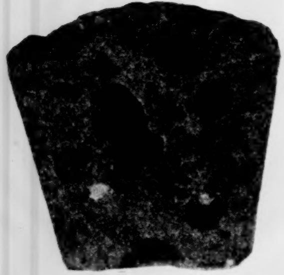


Identification No. 16827, Aluminum
Added. Carbon, 0.18 per cent

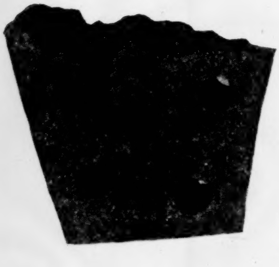
Identification No. 13494, Regular.
Carbon, 0.34 per cent



Identification No. 13494, Aluminum
Added. Carbon, 0.34 per cent

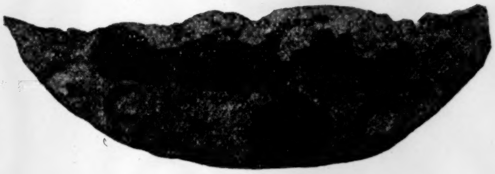


Identification No. 16030, Regular.
Carbon, 0.60 per cent



Identification No. 16030, Aluminum
Added. Carbon, 0.60 per cent

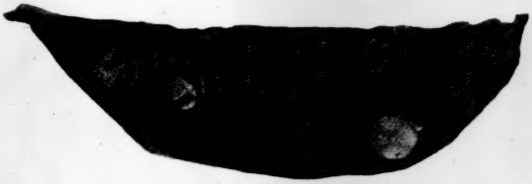
FIG. 3.—Ladle Test Ingots from Company III



Identification No. 08259, Regular. Carbon, 0.48 per cent

Identification No. 08259, Aluminum Added. Carbon, 0.48 per cent

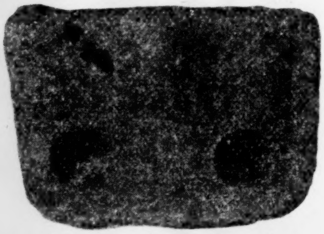
Identification No. 06221, Regular. Carbon, 0.90 per cent



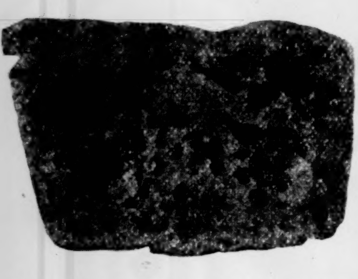
Identification No. 06221, Aluminum Added. Carbon, 0.90 per cent

FIG. 4.—Ladle Test Ingots from Company IV

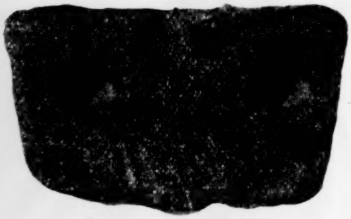
Identification No. K38261, Regular. Carbon, 0.23 per cent



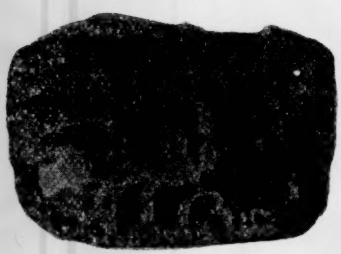
Identification No. K38261, Aluminum Added. Carbon, 0.23 per cent



Identification No. K18–158, Regular. Carbon, 0.61 per cent



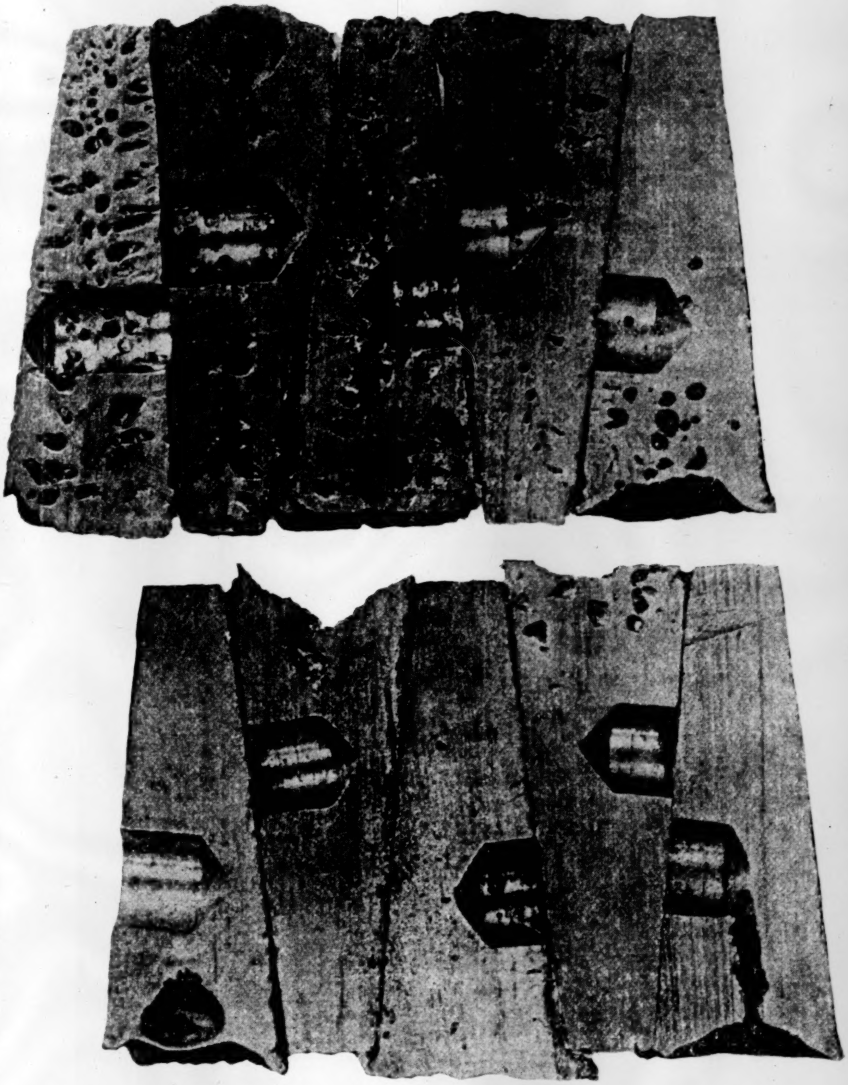
Identification No. K18–158, Aluminum Added. Carbon, 0.62 per cent



Identification No. K33–235, Regular. Carbon, 0.98 per cent

Identification No. K33–235, Aluminum Added. Carbon, 1.00 per cent

FIG. 5.—Ladle Test Ingots from Company VI



With Aluminum Regular

FIG. 6.—Ladle Test Ingots from Company VII, Carbon, 0.50 to 0.80 per cent

SUMMARY OF RESULTS

As a means of studying the segregation data, an ingot having differences of more than 0.02 per cent in carbon between the three positions was classed as segregated; for sulfur and phosphorus 0.003 per cent was chosen as the limit of variation. In Table I, the carbon values have been grouped according to the number of samples varying more than 0.02 per cent and also with respect to carbon content. Inspection of this table shows that for the 72 samples examined, 45 per cent of the regular poured ingots show segregation and for those treated with aluminum 26 per cent are classed as segregated.

TABLE I.—CARBON SURVEY (NUMBER OF SAMPLES HAVING MORE THAN 0.02 PER CENT DIFFERENCE).

Company and Number of Samples from Each	0.15 to 0.30 Per Cent Carbon		0.30 to 0.50 Per Cent Carbon		0.50 to 0.80 Per Cent Carbon		0.80 to 1.10 Per Cent Carbon		Totals, All Carbon Contents			
									Number		Percentage	
	Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added
I (25)	2	2	3	3	4	2	5	3	14	10	56	40
II (16)	0	0	3	0	1	3	1	1	5	4	31	25
III (15)	3	2	1	0	2	0	1	2	7	4	47	27
IV (11)	0	0	2	0	1	1	2	0	5	1	45	9
V (5)	0	0	1	0	0	0	0	0	1	0	20	0
Total (72)	5	4	10	3	8	6	9	6	32	19		
Total number of samples in each group	21		18		19		14		72			

TABLE II.—PHOSPHORUS AND SULFUR SURVEY

Company and Number of Samples from Each	Number of Samples Having Variations							
	Over 0.003 Per Cent		Over 0.004 Per Cent		Over 0.003 Per Cent		Over 0.004 Per Cent	
	Phosphorus				Sulfur			
	Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added
I (25)	8	1	3	1	1	1	1	1
II (16)	0	0	0	0	6	1	4	1
III (15)	0	1	0	0	1	0	1	0
IV (11)	0	0	0	0	0	0	0	0
V (5)	0	0	0	0	1	0	0	0
Total (72)	8	2	3	1	9	2	6	2
Percentage of total samples	11	3	4	1.4	12	3	8	3

For carbon then, ingots treated with aluminum show approximately 19 per cent less segregation than the regular method of secur-

Table III.—Chemical Analyses for Segregation Study

Identification No.	Position of Drilling	Carbon		Phosphorus		Sulfur	
		Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added
Ladle Test Ingots from Company I							
27502	(Mill)	0.13	0.13	0.010	0.010	0.034	0.037
	P-1	0.12	0.13	0.008	0.007	0.035	0.036
	P-2	0.11	0.12	0.007	0.008	0.032	0.036
	P-3	0.14	0.12	0.007	0.007	0.033	0.036
31466	(Mill)	0.12	0.12	0.010	0.010	0.034	0.035
	P-1	0.14	0.12	0.006	0.007	0.031	0.032
	P-2	0.14	0.14	0.007	0.007	0.034	0.034
	P-3	0.15	0.13	0.007	0.008	0.033	0.035
33498	(Mill)	0.11	0.10	0.010	0.010	0.036	0.038
	P-1	0.12	0.14	0.008	0.006	0.036	0.037
	P-2	0.10	0.14	0.006	0.006	0.034	0.036
	P-3	0.11	0.14	0.006	0.006	0.035	0.036
38541	(Mill)	0.10	0.12	0.011	0.011	0.032	0.035
	P-1	0.10	0.10	0.010	0.010	0.032	0.036
	P-2	0.11	0.12	0.009	0.009	0.031	0.035
	P-3	0.12	0.11	0.009	0.009	0.034	0.036
39540	(Mill)	0.12	0.13	0.012	0.012	0.029	0.031
	P-1	0.11	0.12	0.011	0.013	0.028	0.030
	P-2	0.11	0.13	0.012	0.012	0.030	0.028
	P-3	0.12	0.14	0.012	0.013	0.028	0.030
33467	(Mill)	0.22	0.23	0.023	0.024	0.039	0.041
	P-1	0.23	0.23	0.018	0.019	0.039	0.040
	P-2	0.24	0.26	0.018	0.017	0.038	0.040
	P-3	0.22	0.24	0.017	0.018	0.038	0.040
36494	(Mill)	0.31	0.32	0.018	0.019	0.036	0.036
	P-1	0.33	0.34	0.015	0.012	0.035	0.035
	P-2	0.33	0.33	0.014	0.011	0.033	0.036
	P-3	0.32	0.33	0.011	0.011	0.033	0.035
38495	(Mill)	0.22	0.25	0.012	0.012	0.030	0.033
	P-1	0.25	0.24	0.012	0.010	0.032	0.031
	P-2	0.27	0.24	0.009	0.011	0.030	0.032
	P-3	0.26	0.23	0.015	0.010	0.031	0.033
39502	(Mill)	0.27	0.28	0.016	0.016	0.040	0.042
	P-1	0.31	0.32	0.012	0.013	0.038	0.035
	P-2	0.30	0.31	0.012	0.013	0.030	0.036
	P-3	0.35	0.34	0.012	0.011	0.037	0.035
42495	(Mill)	0.20	0.22	0.015	0.015	0.045	0.045
	P-1	0.21	0.21	0.013	0.010	0.045	0.044
	P-2	0.21	0.22	0.011	0.010	0.046	0.046
	P-3	0.21	0.21	0.012	0.009	0.046	0.045
30470	(Mill)	0.36	0.36	0.014	0.014	0.029	0.031
	P-1	0.33	0.36	0.008	0.010	0.030	0.033
	P-2	0.36	0.36	0.008	0.009	0.031	0.032
	P-3	0.37	0.36	0.008	0.008	0.030	0.030
31470	(Mill)	0.51	0.50	0.018	0.017	0.026	0.025
	P-1	0.56	0.52	0.019	0.019	0.029	0.028
	P-2	0.53	0.50	0.019	0.019	0.030	0.028
	P-3	0.57	0.53	0.020	0.020	0.030	0.026
36535	(Mill)	0.47	0.49	0.024	0.026	0.036	0.038
	P-1	0.44	0.55	0.023	0.026	0.036	0.041
	P-2	0.47	0.47	0.024	0.025	0.039	0.040
	P-3	0.47	0.49	0.022	0.025	0.038	0.040
40466	(Mill)	0.45	0.46	0.029	0.029	0.046	0.046
	P-1	0.46	0.46	0.026	0.030	0.035	0.044
	P-2	0.47	0.44	0.027	0.030	0.040	0.045
	P-3	0.48	0.45	0.030	0.029	0.045	0.047
Ladle Test Ingots from Company I—Continued							
41485	(Mill)	0.51	0.50	0.033	0.031	0.044	0.044
	P-1	0.52	0.53	0.029	0.031	0.044	0.043
	P-2	0.53	0.56	0.031	0.031	0.043	0.038
	P-3	0.53	0.54	0.031	0.030	0.045	0.044
29476	(Mill)	0.83	0.80	0.035	0.038	0.032	0.030
	P-1	0.79	0.67	0.032	0.032	0.030	0.027
	P-2	0.79	0.79	0.031	0.034	0.029	0.030
	P-3	0.82	0.78	0.032	0.034	0.030	0.030
30480	(Mill)	0.77	0.75	0.038	0.040	0.035	0.032
	P-1	0.77	0.82	0.034	0.039	0.030	0.033
	P-2	0.77	0.79	0.037	0.036	0.030	0.032
	P-3	0.81	0.79	0.032	0.034	0.028	0.030
35469	(Mill)	0.71	0.70	0.039	0.038	0.040	0.039
	P-1	0.73	0.72	0.038	0.039	0.036	0.039
	P-2	0.71	0.72	0.039	0.040	0.039	0.039
	P-3	0.71	0.72	0.038	0.039	0.037	0.040
39534	(Mill)	0.72	0.71	0.029	0.028	0.029	0.029
	P-1	0.81	0.72	0.033	0.026	0.033	0.030
	P-2	0.74	0.72	0.031	0.027	0.034	0.028
	P-3	0.81	0.72	0.035	0.026	0.032	0.030
46478	(Mill)	0.71	0.69	0.023	0.023	0.027	0.027
	P-1	0.67	0.73	0.022	0.022	0.027	0.030
	P-2	0.70	0.74	0.022	0.022	0.027	0.028
	P-3	0.66	0.73	0.019	0.022	0.025	0.028
30539	(Mill)	1.07	1.07	0.017	0.018	0.036	0.037
	P-1	0.90	1.05	0.015	0.018	0.028	0.031
	P-2	0.95	1.08	0.014	0.017	0.029	0.032
	P-3	1.06	1.00	0.018	0.017	0.030	0.032
33523	(Mill)	0.85	0.94	0.033	0.040	0.036	0.044
	P-1	0.68	0.93	0.033	0.041	0.034	0.040
	P-2	0.64	0.92	0.035	0.042	0.032	0.042
	P-3	0.70	0.91	0.037	0.043	0.032	0.041
33528	(Mill)	1.05	1.11	0.036	0.042	0.029	0.032
	P-1	1.01	1.02	0.041	0.040	0.032	0.030
	P-2	0.90	1.08	0.036	0.042	0.030	0.033
	P-3	1.02	1.07	0.037	0.041	0.030	0.033
44577	(Mill)	1.03	1.06	0.026	0.027	0.027	0.030
	P-1	0.95	1.08	0.023	0.025	0.028	0.026
	P-2	0.86	1.08	0.021	0.025	0.026	0.028
	P-3	0.94	1.08	0.024	0.027	0.028	0.028
45574	(Mill)	0.96	1.01	0.010	0.011	0.027	0.030
	P-1	0.89	1.09	0.016	0.016	0.029	0.031
	P-2	0.92	1.00	0.015	0.018	0.028	0.029
	P-3	0.88	1.04	0.015	0.017	0.028	0.029
Ladle Test Ingots from Company II							
16050	(Mill)	0.15	0.16	0.014	0.014	0.089	0.090
	P-1	0.17	0.17	0.018	0.013	0.088	0.094
	P-2	0.18	0.17	0.018	0.016	0.103	0.091
	P-3	0.18	0.17	0.018	0.016	0.094	0.089
14076	(Mill)	0.16	0.17	0.009	0.009	0.034	0.034
	P-1	0.17	0.20	0.010	0.010	0.037	0.038
	P-2	0.17	0.18	0.008	0.008	0.035	.....
	P-3	0.19	0.18	0.010	0.008	0.036	0.040

TABLE III.—CHEMICAL ANALYSIS FOR SEGREGATION STUDY—(*Continued*)

Identification No.	Position of Drilling	Carbon		Phosphorus		Sulfur	
		Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added
LADLE TEST INGOTS FROM COMPANY II—Continued							
26045	(Mill)	0.20	0.21	0.012	0.011	0.041	0.041
	P-1	0.22	0.23	0.010	0.013	0.041	0.042
	P-2	0.22	0.23	0.012	0.010	0.046	0.042
	P-3	0.23	0.21	0.010	0.010	0.048	0.042
18048	(Mill)	0.19	0.22	0.010	0.010	0.036	0.038
	P-1	0.23	0.22	0.010	0.010	0.041	0.041
	P-2	0.21	0.23	0.010	0.010	0.041	.....
	P-3	0.23	0.22	0.011	0.010	0.043	0.040
18044	(Mill)	0.23	0.24	0.011	0.010	0.040	0.039
	P-1	0.23	0.25	0.008	0.010	0.037	0.040
	P-2	0.25	0.26	0.008	0.009	0.041	0.040
	P-3	0.24	0.24	0.010	0.010	0.039	0.040
20042	(Mill)	0.39	0.40	0.017	0.017	0.037	0.036
	P-1	0.41	0.40	0.016	0.017	0.050	0.036
	P-2	0.40	0.40	0.015	0.015	0.039	0.037
	P-3	0.39	0.41	0.017	0.017	0.036	0.037
21034	(Mill)	0.41	0.41	0.024	0.023	0.045	0.043
	P-1	0.41	0.43	0.022	0.022	0.046	0.044
	P-2	0.43	0.42	0.024	0.022	0.048	0.046
	P-3	0.40	0.41	0.022	0.023	0.046	0.044
15043	(Mill)	0.45	0.47	0.023	0.022	0.041	0.042
	P-1	0.51	0.47	0.022	0.020	0.043	.....
	P-2	0.50	0.48	0.022	0.022	0.044	0.045
	P-3	0.52	0.47	0.020	0.021	0.042	0.045
13038	(Mill)	0.46	0.47	0.024	0.024	0.029	0.031
	P-1	0.46	0.47	0.022	0.022	0.031	0.032
	P-2	0.45	0.47	0.020	0.020	0.030	0.031
	P-3	0.48	0.47	0.020	0.022	0.032	0.031
24038	(Mill)	0.48	0.48	0.020	0.020	0.038	0.038
	P-1	0.45	0.49	0.020	0.022	0.035	0.042
	P-2	0.46	0.49	0.020	0.022	0.037	0.040
	P-3	0.48	0.49	0.020	0.022	0.036	0.040
13159	(Mill)	0.52	0.53	0.019	0.019	0.042	0.042
	P-1	0.53	0.51	0.017	0.017	0.046	0.045
	P-2	0.53	0.55	0.016	0.019	0.048	0.043
	P-3	0.54	0.53	0.017	0.020	0.050	0.044
24052	(Mill)	0.53	0.53	0.020	0.020	0.039	0.037
	P-1	0.52	0.53	0.020	0.018	0.038	0.036
	P-2	0.52	0.53	0.018	0.018	0.038	0.037
	P-3	0.51	0.52	0.019	0.018	0.037	0.037
14068	(Mill)	0.55	0.55	0.019	0.018	0.033	0.031
	P-1	0.56	0.50	0.019	0.018	0.033	0.038
	P-2	0.57	0.53	0.018	0.017	0.033	0.040
	P-3	0.56	0.52	0.020	0.020	0.032	0.038
23062	(Mill)	0.58	0.59	0.023	0.022	0.039	0.039
	P-1	0.56	0.59	0.021	0.020	0.038	0.040
	P-2	0.58	0.62	0.022	0.021	0.036	0.043
	P-3	0.57	0.60	0.021	0.023	0.038	0.041
21112	(Mill)	0.59	0.60	0.018	0.018	0.036	0.035
	P-1	0.57	0.60	0.019	0.020	0.038	0.038
	P-2	0.57	0.58	0.020	0.018	0.041	0.038
	P-3	0.63	0.58	0.020	0.018	0.046	0.038
21150	(Mill)	0.81	0.81	0.045	0.045	0.051	0.051
	P-1	0.81	0.82	0.046	0.045	0.053	0.053
	P-2	0.81	0.81	0.047	0.045	0.054	0.054
	P-3	0.88	0.84	0.048	0.044	0.052	0.052
LADLE TEST INGOTS FROM COMPANY III							
13427	(Mill)	0.17	0.18	0.020	0.020	0.044	0.047
	P-1	0.18	0.20	0.016	0.016	0.044	0.046
	P-2	0.18	0.19	0.017	0.016	0.044	0.048
	P-3	0.17	0.19	0.016	0.016	0.044	0.049
16827	(Mill)	0.18	0.18	0.030	0.030	0.043	0.044
	P-1	0.25	0.19	0.026	0.025	0.043	0.046
	P-2	0.18	0.19	0.025	0.025	0.042	0.046
	P-3	0.20	0.18	0.025	0.025	0.041	0.044
16832	(Mill)	0.19	0.19	0.027	0.026	0.043	0.044
	P-1	0.19	0.20	0.027	0.030	0.041	0.043
	P-2	0.22	0.19	0.029	0.026	0.043	0.044
	P-3	0.18	0.20	0.028	0.030	0.040	0.042
14622	(Mill)	0.22	0.24	0.018	0.019	0.043	0.048
	P-1	0.29	0.31	0.018	0.018	0.040	0.045
	P-2	0.25	0.28	0.017	0.019	0.035	0.046
	P-3	0.28	0.28	0.017	0.019	0.038	0.045
14392	(Mill)	0.25	0.26	0.010	0.011	0.046	0.049
	P-1	0.26	0.31	0.010	0.010	0.046	0.049
	P-2	0.27	0.26	0.008	0.008	0.047	0.048
	P-3	0.26	0.28	0.009	0.009	0.046	0.049
14322	(Mill)	0.30	0.30	0.036	0.035	0.060	0.060
	P-1	0.35	0.34	0.032	0.032	0.058	0.057
	P-2	0.34	0.33	0.031	0.032	0.060	0.057
	P-3	0.33	0.33	0.032	0.030	0.058	0.059
13442	(Mill)	0.32	0.32	0.030	0.030	0.048	0.050
	P-1	0.33	0.33	0.031	0.029	0.048	0.046
	P-2	0.33	0.33	0.030	0.030	0.047	0.045
	P-3	0.33	0.33	0.029	0.029	0.046	0.045
13494	(Mill)	0.34	0.34	0.012	0.012	0.043	0.048
	P-1	0.35	0.36	0.013	0.013	0.050	0.045
	P-2	0.36	0.38	0.012	0.013	0.051	0.045
	P-3	0.35	0.36	0.012	0.012	0.049	0.043
12655	(Mill)	0.45	0.45	0.020	0.019	0.049	0.048
	P-1	0.46	0.45	0.019	0.018	0.045	0.043
	P-2	0.47	0.44	0.018	0.019	0.047	0.045
	P-3	0.45	0.45	0.019	0.019	0.045	0.045
14331	(Mill)	0.46	0.46	0.036	0.035	0.050	0.050
	P-1	0.49	0.47	0.033	0.033	0.050	0.050
	P-2	0.47	0.47	0.032	0.031	0.050	0.050
	P-3	0.46	0.47	0.032	0.033	0.050	0.050
13453	(Mill)	0.52	0.51	0.021	0.020	0.043	0.044
	P-1	0.53	0.51	0.016	0.017	0.041	0.046
	P-2	0.50	0.52	0.016	0.016	0.044	0.045
	P-3	0.51	0.53	0.016	0.016	0.043	0.045
16030	(Mill)	0.60	0.60	0.026	0.024	0.039	0.036
	P-1	0.60	0.62	0.028	0.025	0.036	0.041
	P-2	0.61	0.62	0.026	0.026	0.036	0.042
	P-3	0.60	0.62	0.026	0.023	0.037	0.041
13747	(Mill)	0.71	0.72	0.022	0.023	0.038	0.039
	P-1	0.73	0.70	0.024	0.024	0.036	0.041
	P-2	0.66	0.72	0.026	0.025	0.038	0.038
	P-3	0.69	0.70	0.026	0.024	0.038	0.040
12539	(Mill)	0.81	0.81	0.025	0.028	0.040	0.041
	P-1	0.82	0.82	0.025	0.024	0.040	0.039
	P-2	0.82	0.84	0.025	0.026	0.038	0.040
	P-3	0.81	0.86	0.024	0.024	0.039	0.039
13550	(Mill)	0.92	0.95	0.025	0.027	0.049	0.050
	P-1	0.92	0.98	0.027	0.026	0.038	0.046
	P-2	0.92	0.96	0.026	0.026	0.037	0.045
	P-3	0.99	0.94	0.026	0.026	.....	0.045

TABLE III.—CHEMICAL ANALYSIS FOR SEGREGATION STUDY—(*Continued*)

Identification No.	Position of Drilling	Carbon		Phosphorus		Sulfur	
		Regular	Aluminum Added	Regular	Aluminum Added	Regular	Aluminum Added
LADLE TEST INGOTS FROM COMPANY IV							
04208	(Mill)	0.31	0.31	0.014	0.013	0.036	0.039
	P-1	0.30	0.27	0.012	0.011	0.044	0.044
	P-2	0.27	0.29	0.012	0.011	0.043	0.046
08259	(Mill)	0.48	0.48	0.018	0.015	0.020	0.020
	P-1	0.50	0.48	0.012	0.013	0.022	0.025
	P-2	0.47	0.49	0.012	0.013	0.024	0.023
04165	(Mill)	0.72	0.71	0.012	0.010	0.032	0.034
	P-1	0.76	0.71	0.010	0.012	0.033	0.031
	P-2	0.72	0.71	0.010	0.012	0.031	0.031
04167	(Mill)	0.61	0.59	0.006	0.008	0.031	0.034
	P-1	0.61	0.60	0.007	0.009	0.028	0.028
	P-2	0.63	0.60	0.006	0.009	0.027	0.029
04325	(Mill)	0.69	0.68	0.010	0.009	0.038	0.036
	P-1	0.68	0.67	0.008	0.010	0.035	0.035
	P-2	0.68	0.69	0.009	0.010	0.037	0.035
08277	(Mill)	0.58	0.54	0.013	0.013	0.027	0.027
	P-1	0.57	0.52	0.008	0.010	0.032	0.035
	P-2	0.55	0.55	0.007	0.011	0.033	0.033
09197	(Mill)	0.82	0.82	0.016	0.016	0.027	0.025
	P-1	0.81	0.80	0.013	0.011	0.030	0.027
	P-2	0.81	0.81	0.013	0.011	0.029	0.029
08220	(Mill)	0.84	0.85	0.015	0.015	0.027	0.027
	P-1	0.84	0.85	0.009	0.009	0.034	0.032
	P-2	0.82	0.85	0.009	0.009	0.032	0.033
08249	(Mill)	0.85	0.85	0.017	0.017	0.027	0.024
	P-1	0.87	0.86	0.010	0.011	0.026	0.026
	P-2	0.86	0.86	0.010	0.011	0.027	0.026
LADLE TEST INGOTS FROM COMPANY IV—Continued							
06207	(Mill)	0.86	0.86	0.018	0.018	0.029	0.032
	P-1	0.91	0.87	0.013	0.013	0.030	0.032
	P-2	0.88	0.87	0.012	0.013	0.032	0.033
06221	(Mill)	0.90	0.90	0.013	0.017	0.028	0.030
	P-1	0.91	0.90	0.009	0.009	0.029	0.024
	P-2	0.94	0.92	0.010	0.011	0.030	0.026
LADLE TEST INGOTS FROM COMPANY V							
1	(Mill)	0.16	0.16	0.025	0.025	0.055	0.054
	P-1	0.17	0.16	0.022	0.022	0.062	0.060
	P-2	0.16	0.15	0.024	0.022	0.063	0.058
	P-3	0.18	0.15	0.023	0.022	0.063	0.059
2	(Mill)	0.35	0.37	0.075	0.074	0.058	0.063
	P-1	0.37	0.33	0.072	0.073	0.066	0.066
	P-2	0.34	0.33	0.072	0.072	0.068	0.066
	P-3	0.33	0.33	0.074	0.071	0.068	0.064
3	(Mill)	0.58	0.57	0.028	0.027	0.034	0.034
	P-1	0.57	0.57	0.027	0.026	0.039	0.037
	P-2	0.55	0.55	0.026	0.028	0.038	0.037
	P-3	0.55	0.55	0.027	0.028	0.035	0.038
4	(Mill)	0.55	0.55	0.014	0.015	0.036	0.036
	P-1	0.55	0.58	0.012	0.013	0.037	0.039
	P-2	0.55	0.56	0.013	0.012	0.039	0.040
	P-3	0.57	0.57	0.013	0.012	0.038	0.039
5	(Mill)	0.98	0.98	0.025	0.027	0.031	0.031
	P-1	1.03	1.04	0.027	0.028	0.033	0.035
	P-2	1.01	1.02	0.026	0.026	0.033	0.035
	P-3	1.02	1.01	0.025	0.025	0.033	0.036

ing test ingots. No relation between decrease in carbon segregation and varying carbon content could be drawn from these data, although both regular and treated ingots show a slight tendency to increase in segregation as the percentage of carbon increases.

In Table II, phosphorus and sulfur results are grouped according to companies and the number of samples are indicated that vary over 0.003 and over 0.004 per cent in the three positions. It will be noted that there is very little difference between the treated and untreated ingots in the case of phosphorus and sulfur. However, there is a little less segregation for both these elements where aluminum has been used.

Inspection of Figs. 1 to 6 shows in general the better appearance and uniformity of the treated ingots. The physical condition of these various ingots together with the chemical survey shows that all types of test ingots which were investigated would be satisfactory if aluminum treatment were employed. A number of pertinent facts regarding ladle test practice are worthy of note. The position of the drill hole in relation to the shape and size of the ingot will often determine whether a satisfactory sample can be taken when the ingot contains blow-holes. Certain types of ingots can be drilled through while others limit drilling to one place. It is of advantage then to favor ingot shapes, which, in necessary cases, can either be readily drilled through or else permit of drilling at some position not likely to be affected by blow-holes. The disadvantage of specimens containing blow-holes is discussed in the report of 1916, referred to previously.

CONCLUSIONS

The following conclusions can be drawn from the work reported:

1. Aluminum treated ingots show approximately 19 per cent less segregation in carbon than the regular ingots.
2. The effect of aluminum treatment on the chemical homogeneity of phosphorus and sulfur is slight.
3. All types of ingots investigated are satisfactory when aluminum treatment is used.
4. Ingots treated with aluminum, due to improved soundness, permit of greater convenience in locating drill holes, and in securing drillings of uniform size free from scale or oxide.

EFFECT OF "ADDED" SULFUR ON STRUCTURAL, FORGING AND RAIL STEELS

SECOND PRELIMINARY REPORT OF THE JOINT COMMITTEE ON INVESTIGATION OF PHOSPHORUS AND SULFUR IN STEEL[1]

The first preliminary report of the Joint Committee on Investigation of Phosphorus and Sulfur in Steel dealt with the Effect of Sulfur on Rivet Steel,[2] and described the tests made on material comprising Group I, Series A, as classified in that report of the committee.[3] In Series A material, the sulfur present is residual, that is, present in the steel through its presence in fuel, pig or scrap and not through additions made in the ladle or mold.

The present report deals with material classed under Series B, in which sulfur has been added during the later stages of manufacture before reaching the ingot mold.

The tests have been made in duplicate, with certain exceptions noted later, at the laboratories of Watertown Arsenal, Watertown, Mass., and the U. S. Naval Engineering Experiment Station, Annapolis, Md. Methods of testing were carefully prescribed in advance and followed in each laboratory as nearly as possible. A third set of material is held in reserve at the U. S. Bureau of Standards.

The magnitude of the investigation of Series B material is indicated by the fact that 236 samples were analyzed chemically for seven elements involving nearly 1700 separate determinations, and something over 5500 physical tests were made.

The complete investigation with full descriptive matter will ultimately be published as a technologic paper of the U. S. Bureau of Standards. The Joint Committee, however, desires to make the data available as soon as possible for the information of all interested and to bring out comment and discussion. The present preliminary report is therefore made to the constituent organizations and, with the approval of the Bureau of Standards, will be published in the Proceedings of the American Society for Testing Materials. The report is limited to the presentation of the essential data in graphical form, with only sufficient explanatory text to make the report clear and self-contained. The complete publication will contain tables, photomicrographs, illustrations of specimens and much descriptive matter that are omitted from the present report.

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[1] Published by permission of the U. S. Bureau of Standards, the U. S. War Department and the U. S. Navy Department.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 94 (1922).

[3] For a brief statement of the organization of the Joint Committee and an outline of the investigation it has planned, see Appendix to this report.

Although the Joint Committee has fully reviewed all the test data herein presented, it has been decided for the present to defer the drawing and publishing of formal conclusions.

The committee wishes to acknowledge its indebtedness to Mr. Quincy Bent, Vice-President of the Bethlehem Steel Co., and Mr. H. T. Morris, Metallurgical Engineer of the Bethlehem Steel Co., who collaborated in the securing of the steel for this investigation; to Mr. A. L. Meyer, Metallurgical Engineer, Alan Wood Iron and Steel Co., who has assisted Mr. E. F. Kenney in the committee work; and Mr. N. Richardson, who has assisted Mr. F. C. Langenberg in the work of the Committee on Tests.

DESCRIPTION OF MATERIAL

The steel for this investigation was manufactured by the Bethlehem Steel Co. at its Bethlehem Plant. In July, 1920, the Committee on Manufacture of the Joint Committee visited this plant and witnessed the manufacture of three heats of basic open-hearth steel. These heats were intended to cover three groups of steel, namely, Plate and Structural Steels, Forging Steels, and Wheel, Tire and Rail Steels. The desired compositions and those obtained, as determined by ladle analysis from the heat, are given in Table I.

The steel was made in 45-ton oil-fired basic furnaces, and regular commercial practice was followed as closely as possible throughout.

From each of these three heats the committee desired to secure eight ingots of sulfur content as nearly as possible as follows:

INGOT No.	DESIRED SULFUR CONTENT, PER CENT
1	0.04
2	0.05
3	0.06
4	0.07
5	0.08
6	0.10
7	0.12
8	0.15

This was done by adding iron sulfide during the pouring of ingots Nos. 2 to 8, inclusive. The procedure in the case of each heat was as follows: A pouring box was provided of sufficient capacity to contain the steel required for one 3200-lb. ingot, 16 by 16 by 57 in., inverted type. The box contained a nozzle and stopper, allowing the full contents of an ingot of this size to accumulate. After pouring 18,000 lb. of metal into ingots not required in the experiment, ingot No. 1 was poured with no sulfur addition. The necessary quantities of iron sulfide[1] to produce the desired sulfur contents for each of the remaining seven ingots having been weighed out, the sulfide was added in a stream from the ladle while each box full of metal was being accumulated for these seven ingots. In pouring the ingots of Group II, the iron sulfide was not added till the pouring box was partly full; in pouring the ingots of Groups III and IV, the sulfide was added as soon as the bottom of the pouring box was covered. The manufacturer believes that on this account the sulfur was probably more uniformly mixed in the pouring box in the last two groups. In all cases the steel lay "quiet" in the molds. The steel of each heat remaining after the pouring of the eighth ingot amounted to more than one-half of the total melted and was not required for the investigation.

TABLE I.—CHEMICAL COMPOSITIONS OF THREE HEATS OF STEEL, SERIES B

The compositions reported as "obtained" were determined by ladle analysis from the heat.

Group No.[a]	Material		Chemical Composition, per cent				
			Carbon	Manganese	Phosphorus	Sulfur	Silicon
II	Structural Steel......	Desired...	0.18 – 0.22	0.50 – 0.70	Below 0.04	Below 0.04	0.10 – 0.20
		Obtained..	0.20	0.50	0.016	0.042	0.196
III	Forging Steel........	Desired...	0.35 – 0.45	0.50 – 0.70	Below 0.04	Below 0.04	0.10 – 0.20
		Obtained..	0.388	0.57	0.010	0.035	0.212
IV	Rail Steel...........	Desired...	0.65 – 0.75	0.50 – 0.70	Below 0.04	Below 0.04	0.10 – 0.20
		Obtained.	0.786	0.61	0.011	0.039	0.198

[a] For significance of Group Numbers, see Appendix, p. 136.

The ingots were allowed to cool (but not to atmospheric temperature), were reheated and rolled into 4 by 4-in. billets. These billets were bloomed as in regular commercial practice. From one of the billets in the lower half of each ingot there was rolled a bar 1 in. in diameter and long enough to allow four 8-ft. long sections to be cut. Each 8-ft. section was carefully marked with a distinguishing code before shipment to the three experiment stations. The billets were chipped to remove cracks and tears before rolling into 1-in. rounds. The ingots from heats of Groups III and IV rolled better than those from Group II. All of the billets rolled satisfactorily into 1-in. rounds. The manufacture up to this stage was completed in three days (July 12-14). The manufacturer, at the request of the Committee, set aside about 400 lb. of 4 by 4-in. billets from each ingot; and the top discards of about 50 per cent of each ingot, for subsequent use as the Committee might later indicate.

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[1] The iron sulfide showed, by analysis, sulfur, 27.6 per cent; iron, 69.5 per cent; manganese, 0.28 per cent; silicon, 0.06 per cent; phosphorus, a trace; copper and nickel, not detected. The material was not homogeneous, but the main portion melted at 1080° C. (1976° F.), and there was some part left that was apparently iron or steel.

In December, 1921, the billets reserved were rolled into bars 1 in. in diameter and flats 4½ in. wide and 1 in. thick. The flats were rolled in lengthwise direction only. The billets from ingots Nos. 1 and 2 had through misunderstanding been scrapped; but there were secured at this time, representing each of ingots Nos. 3 to 8, inclusive, for each of the three heats, nine bars about 9 ft. long and three flats about 4 ft. 6 in. long. All of the billets rolled satisfactorily.

At this time top discards from these six ingots of each heat were remelted in two heats, producing a special series of steel with residual sulfur of approximately 0.08 and 0.12 per cent, comparable with the Series B material.[1]

Complete data on the manufacture and fabrication of the test material have been furnished to the committee. The average contents of sulfur, carbon, manganese, phosphorus, silicon, nickel and chromium, as determined by analyses from the test material, are given in Table II.

DESCRIPTION OF TEST SPECIMENS AND METHODS

One set of material was tested at the laboratory of Watertown Arsenal and a duplicate set was tested at the U. S. Naval Engineering Experiment Station. The test procedures outlined at the beginning of the investigation were followed as carefully and closely as possible by the two laboratories, so that the committee has obtained directly comparable test data from two separate laboratories on material identical for all practical purposes. A brief description of the tests and methods follows.

The material was tested in the longitudinal direction of rolling, the specimens being taken from the round bars, and transverse to the direction of rolling, the specimens being taken from the flats with their longitudinal axes perpendicular to the direction of rolling. For convenience, these are designated hereafter as "longitudinal" and "transverse" material. In the direction of rolling, the material was tested in tension, impact (Charpy and impact shear), hardness (Brinell and scleroscope), bending, torsion and shear. Transverse to the direction of rolling, the material was tested in tension, impact (Charpy), hardness (Brinell and scleroscope), bending and shear. The material was tested in the natural condition "as received," in normalized condition, and in quenched or quenched-and-drawn condition.

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[1] The testing of the specimens from this special series has not yet been completed. The report on this part of the investigation is therefore deferred.

TABLE II.—AVERAGE CHEMICAL COMPOSITIONS, WITH MEAN DIVERGENCIES, SERIES B MATERIAL

The sulfur contents reported are the average of 7 determinations for ingots Nos. 1 and 2 of each heat and 14 to 16 determinations for the remaining six ingots of each heat, counting the analyses of the composite sample at the Naval Experiment Station as the equivalent of 4 individual analyses. The mean divergences from the average sulfur contents are with respect to the individual analyses at Watertown Arsenal.

The contents of the remaining elements reported are the average of values obtained by the two laboratories for each of the eight ingots of each heat, these values in turn being an average of the number of individual determinations noted above. The mean divergences of these average values from the values reported are recorded.

Group No.	Ingot No.	Sulfur, per cent	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Silicon, per cent	Nickel, per cent	Chromium, per cent
II	1	0.033±0.0040	0.202±0.010	0.503±0.015	0.013±0.001	0.194±0.012	0.191±0.033	0.038±0.008
	2	0.039±0.0060						
	3	0.059±0.0024						
	4	0.066±0.0035						
	5	0.078±0.0015						
	6	0.074±0.0028						
	7	0.133±0.0031						
	8	0.136±0.0018						
III	1	0.026±0.0040	0.371±0.006	0.604±0.023	0.010±0.001	0.212±0.016	0.299±0.024	0.039±0.009
	2	0.043±0.0025						
	3	0.060±0.0007						
	4	0.067±0.0020						
	5	0.080±0.0015						
	6	0.102±0.0015						
	7	0.113±0.0036						
	8	0.152±0.0060						
IV	1	0.033±0.0026	0.777±0.017	0.627±0.023	0.015±0.001	0.200±0.012	0.156±0.033	0.050±0.02
	2	0.052±0.0013						
	3	0.060±0.0015						
	4	0.071±0.0016						
	5	0.083±0.0015						
	6	0.113±0.0018						
	7	0.128±0.0036						
	8	0.153±0.0063						

Chemical Analyses—At Watertown Arsenal, separate chemical analyses were made on drillings taken from broken test specimens from "longitudinal" and "transverse" material, while at the Naval Experiment Station analyses were made from a composite sample consisting of samples from each end of two bars from each ingot. Sulfur, carbon, manganese, phosphorus, silicon, nickel and chromium were determined by the methods specified by the American Society for Testing Materials. Counting the analyses of the composite sample at the Naval Experiment Station as the equivalent of four individual analyses, to compare with the method adopted at the Watertown Arsenal, the chemical compositions herein reported are the average of seven determinations of each element from ingots Nos. 1 and 2 of each heat, and 14 to 16 determinations from the remaining six ingots of each heat.

Heat Treatment.—Material from Group II was tested in natural, normalized and quenched conditions. Material from Groups III and IV was tested in natural, normalized and quenched-and-drawn conditions, with the exception that no "transverse" material was tested in the natural condition. The material was first cut up into the required number of specimens. For Group II material, the normalized condition was obtained by heating the pieces thus obtained to 870° C. (1600° F.), holding for one hour[1] and cooling in air; the quenched condition, by heating to the same temperature, holding for one hour and quenching in water at 21° C. (70° F.) For Groups III and IV material, having higher carbon, the following procedures were followed: For normalized condition, heating to 815° C. (1500° F.), holding for one hour[1] and cooling in air; for quenched-and-drawn condition, heating to 815° C. (1500° F.), holding for one hour,[1] quenching in oil, reheating to 575° C. (1070° F.), holding for one hour[1] and cooling in furnace. All machine work on specimens requiring machining was done after heat treatment.

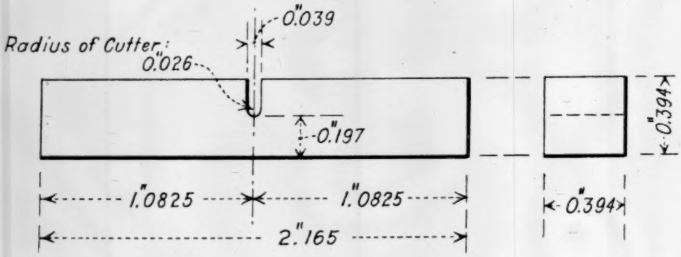

FIG. 1.—Test Specimen for Charpy Impact Test[2]

Number of Tests.—For the most part, the tests were duplicated at the two laboratories, although there were some exceptions. The tests made at each laboratory for each of the three heats, and the number of specimens tested per ingot, are recorded in Table III.

Specimens.—Test specimens of the same dimensions were used at the two laboratories, and in general were as reported in the First Preliminary Report on Tests of Rivet Steel. The tension test specimen was the A.S.T.M. standard, 0.505 in. in diameter and 2-in. gage length with threaded ends. The Charpy impact test specimen is illustrated in Fig. 1. The impact shear specimen (unnotched) was $\frac{3}{8}$ by $\frac{1}{4}$ by 3 in. At Watertown Arsenal the bend test specimen for the round bars was full size with the scale just turned off; for flats,

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[1] At the Naval Experiment Station, "longitudinal" material was held at the various heats for one-half hour instead of one hour.

[2] **Specimen illustrated is that used at Watertown Arsenal. Specimen used at Naval Experiment Station differed only in that the radius at the bottom of the notch was 0.0197 in.**

TABLE III.—NUMBER OF TESTS PER INGOT MADE BY EACH LABORATORY FOR GROUPS II, III AND IV, SERIES B

Group	Direction of Testing	Condition of Material	Laboratory[1]	Kind of Test								
					Impact			Hardness				
				Tension	Charpy	Charpy—Transverse; Impact Perpendicular to Direction of Rolling	Impact Shear	Brinell	Scleroscope	Bend	Torsion	Shear
II	Longitudinal	Natural	W.A.	6	8	..	none	2	2	6	6	6
			N.E.S.	3	4	..	16	2	2	3	3	none
		Normalized	W.A.	6	8	..	none	2	2	6	6	6
			N.E.S.	3	4	..	16	2	2	3	3	none
		Quenched	W.A.	6	8	..	none	2	2	6	6	6
			N.E.S.	2	2	..	4	2	2	1	2	none
	Transverse	Natural	W.A.	6	8	none	none	2	2	3	none	none
			N.E.S.	3	2	2	none	2	2	2	none	2
		Normalized	W.A.	6	8	none	none	2	2	3	none	none
			N.E.S.	3	2	2	none	2	2	2	none	2
		Quenched	W.A.	none	none	none	none	none	none	none	none	none
			N.E.S.	3	2	2	none	2	2	2	none	2
III	Longitudinal	Natural	W.A.	6	8	..	none	2	2	3	6	6
			N.E.S.	none	none	..	none	none	none	none	none	none
		Normalized	W.A.	6	8	..	none	2	2	6	6	6
			N.E.S.	3	4	..	16	2	2	3	3	none
		Quenched and Drawn	W.A.	6	8	..	none	2	2	6	6	6
			N.E.S.	3	4	..	16	2	2	3	3	none
	Transverse	Normalized	W.A.	6	8	none	none	2	2	3	none	none
			N.E.S.	3	2	2	none	2	2	2	none	2
		Quenched and Drawn	W.A.	6	8	none	none	2	2	3	none	none
			N.E.S.	3	2	2	none	2	2	2	none	2
IV	Longitudinal	Natural	W.A.	6	8	..	none	2	2	3	6	6
			N.E.S.	none	none	..	none	none	none	none	none	none
		Normalized	W.A.	6	8	..	none	2	2	6	6	6
			N.E.S.	3	4	..	16	2	2	2	3	none
		Quenched and Drawn	W.A.	6	8	..	none	2	2	6	6	6
			N.E.S.	3	4	..	16	2	2	2	3	none
	Transverse	Normalized	W.A.	6	8	none	none	2	2	3	none	none
			N.E.S.	3	2	2	none	2	2	2	none	2
		Quenched and Drawn	W.A.	6	8	none	none	2	2	3	none	none
			N.E.S.	3	2	2	none	2	2	2	none	2

[1] W.A. = Watertown Arsenal Laboratory.
N.E.S. = U. S. Naval Engineering Experiment Station.

the round specimen was used, turned to a diameter of 0.8125 in. At the Naval Experiment Station the bend test specimen for all material was machined to 1 by $\frac{1}{2}$ in. in cross-section with the corners rounded to a radius of $\frac{1}{16}$ in. The torsion test specimen ($9\frac{1}{4}$ in. long) was turned to a diameter of $\frac{3}{4}$ in. for a length of $5\frac{1}{4}$ in. with fillets at the shoulder of $\frac{3}{8}$ in. radius. The shear tests on "longitudinal" material were made on full-size specimens; on "transverse" material the specimens were turned to $\frac{1}{2}$ in. in diameter. All specimens were tested in double shear. All machine work was done at the respective laboratories.

Methods.—In general the standard methods of the American Society for Testing Materials were followed where applicable. The methods described in detail in the First Preliminary Report on Tests of Rivet Steel[1] were followed in the present series of tests.

In the case of the specimens from the flats taken transversely to the direction of rolling, Charpy impact tests at the Naval Experiment Station were made with the direction of impact both in the direction of the long dimension of the flat and at right angles to the long dimension of the flat.

In making the bend tests on specimens taken in the transverse direction, the specimens were bent in the direction perpendicular to that of the long dimension of the flat, the bending in all cases being done with the 1-in. face of the specimen against the die block.

PRESENTATION OF TEST DATA

In order to obtain a uniform basis for plotting the physical properties determined, the committee averaged the sulfur contents reported by the two laboratories for each of the eight ingots of each of the three heats. These average values are given in Table II, together with the mean divergences therefrom of the individual determinations made at Watertown Arsenal. (As previously stated, only one determination of the composite sample from each ingot was made at the Naval Experiment Station.) In this table are also reported the average values of carbon, manganese, phosphorus, silicon, nickel and chromium for each heat, determined by averaging the average values for these elements obtained in the two laboratories from samples taken from the respective ingots. The mean divergences of these values from the average are also given. A comparison of these values with the chemical compositions reported in Table I as determined by ladle analysis is interesting.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, pp. 101–102 (1922).

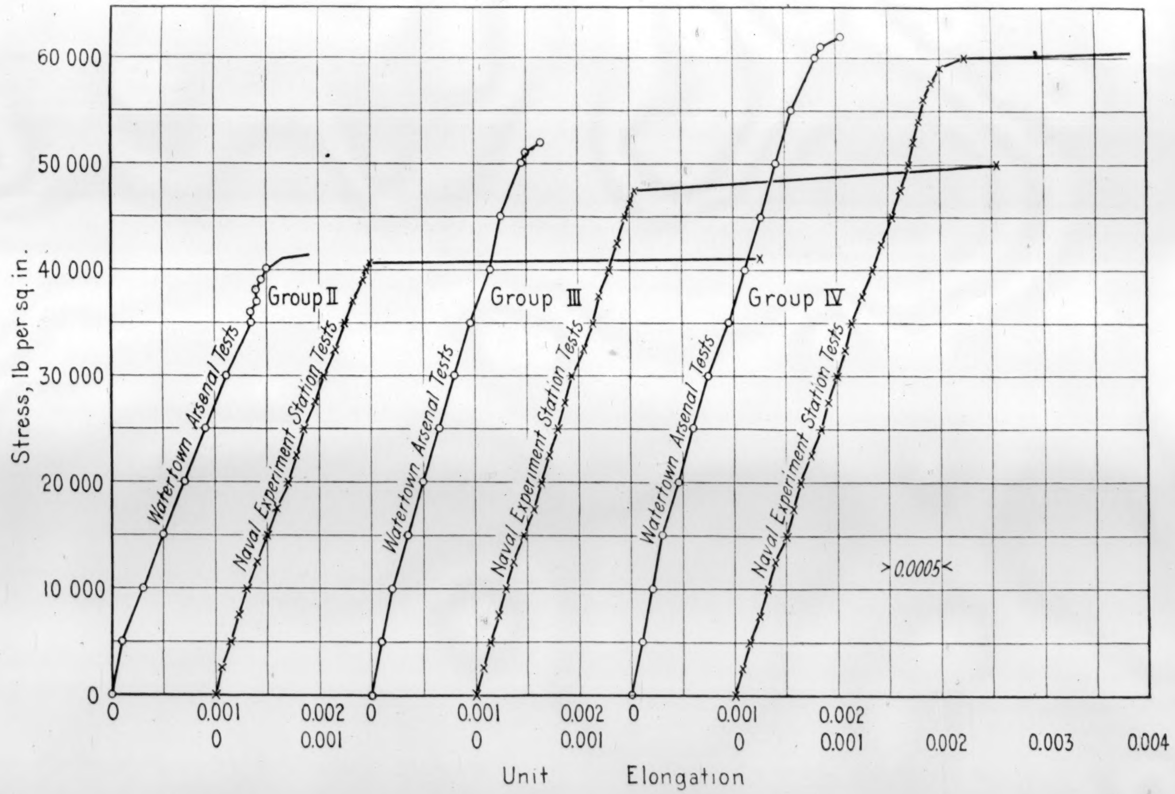

FIG. 2.—Typical Stress-Strain Curves. Material from Groups II, III and IV. Normalized Condition

For the purpose of this preliminary report, all of the data on physical tests are presented in graphical rather than tabular form, since the use of curves permits of far readier study of the significance of the tests. In the figures that follow, the percentages of sulfur are plotted as abscissas and the various properties determined are plotted as ordinates. Light vertical dotted lines are drawn at the average sulfur contents of each ingot of each group (Table II) and are marked with the corresponding ingot numbers. The endeavor has been made to use the same vertical scales in plotting the same properties in the various figures, and to use proportionate scales in plotting properties expressed in different units, although this has not always been found feasible because of the wide divergence in the values reported for certain properties. The results obtained at the two laboratories are plotted separately and straight lines have been drawn connecting the average of the values obtained at the two laboratories for successive ingots, these averages being determined with regard to the number of tests of which each plotted value is the average.

Separate curves have been drawn for tests on longitudinal and transverse material in the natural, normalized and quenched or quenched-and-drawn conditions. An examination of the figures will reveal a very satisfactory agreement between the results obtained at the two laboratories.

Typical stress-strain curves of tension specimens from bar material in the normalized condition for each of the three groups are shown in Fig. 2. These are typical of the stress-strain curves obtained in this investigation.

The test data for Group II material are plotted in Figs. 3 to 16, inclusive; for Group III material in Figs. 17 to 28, inclusive; and for Group IV material in Figs. 29 to 40, inclusive. In reporting the results of tension tests (Figs. 3 to 8, 17 to 21 and 29 to 33), proportional limit, yield point, tensile strength, elongation in 2 in. and reduction of area are plotted. Brinell and scleroscope hardness values are plotted in Figs. 9, 10, 22 and 34. In the figures for impact values (Figs. 11, 12, 23, 24, 35 and 36), Charpy and impact shear are plotted, the latter only for "longitudinal" material. In the impact tests of "transverse" material at the Naval Experiment Station, Charpy impact values were determined with the direction of impact parallel to the direction of rolling and perpendicular to the direction of rolling. Both of thesevalues are reported in Figs. 12, 24 and 36. The results of the bend tests are given in detail in Table IV. In reporting the results of torsion tests (Figs. 13 to 15, 25 to 27, and 37 to 39), stress at proportional limit, stress at maximum torque, angle of twist

TABLE IV.—RESULTS OF BEND TESTS OF MATERIAL IN GROUPS II, III AND IV, SERIES B

Bend tests at Watertown Arsenal (designated W. A.) were made for "longitudinal" material on full size bars with scale just turned off; for "transverse" material on bars turned to a diameter of 0.8125 in.

Bend tests at Naval Experiment Station (designated N.E.S.) were made for both "longitudinal" and "transverse" material on specimens machined to 1 by ½ in. in cross-section with the corners rounded to a radius of $\frac{1}{16}$ in., which were tested with the 1-in. face of the specimens against the die block.

The number of specimens tested for each ingot in each condition is reported in the table.

O.K. = Specimen bent 180 deg. flat on itself without fracture.

Cr. = Specimen showed one or more small cracks at the angle designated.

Br. = Specimen showed one or more large cracks at the angle designated.

F. = Specimen broke suddenly in two at the angle designated.

Group No.	How Tested	Ingot No.	Heat Treatment					
			Natural		Normalized		Quenched	
			W.A.	N.E.S.	W.A.	N.E.S.	W.A.	N.E.S.
II	Longitudinal	1	3 O.K.	3 O.K.	3 O.K.	3 O.K.	3 O.K.	1 Cr. 180°
		2	"	"	"	"	"	1 O.K.
		3	6 O.K.	2 O.K.; 1 Cr. 180°	6 O.K.	"	5 O.K.; 1 Cr. 180°	1 Cr. 180°
		4	"	3 O.K.	"	"	6 O.K.	1 O.K.
		5	"	"	"	3 Cr. 180°	5 O.K.; 1 Cr. 180°	1 Cr. 180°
		6	"	2 O.K.; 1 Cr. 180°	"	3 O.K.	6 O.K.	"
		7	"	1 O.K.; 1 Cr. 180°; 1 Br. 180°	"	2 O.K.; 1 Cr. 180°	"	"
		8	"	2 O.K.; 1 Br. 180°	"	3 O.K.	5 O.K.; 1 Br. 180°	1 Cr. 160°
	Transverse	3	3 Br. 100, 100, 120°	1 Br. 106°; 1 Cr. 110°	3 Br. 100, 120, 120°	2 Cr. 118, 120°	....	1 Cr. 91°; 1 Br. 101°
		4	3 Br. 90, 100, 100°	1 Br. 86°; 1 Cr. 120°	"	1 Br. 104°; 1 Cr. 119°	.....	2 Br. 84, 90°
		5	3 Br. 100°	1 Br. 100°; 1 Cr. 111°	"	2 Br. 110, 117°	....	2 Br. 63, 72°
		6	3 Br. 90, 100, 120°	2 Cr. 106, 111°	"	1 Br. 120°; 1 Cr. 121°	....	2 Cr. 58, 77°
		7	3 Br. 90°	2 Br. 74, 103°	3 Br. 100, 100, 120°	1 Br. 93°; 1 Cr. 98°	....	2 Br. 52, 76°
		8	3 Br. 90, 90, 100°	2 Br. 63, 72°	3 Br. 120°	2 Br. 71, 76°	....	2 Br. 46, 48°
							Quenched and Drawn	
III	Longitudinal	1	3 O.K.	....	3 O.K.	1 O.K.; 2 Cr. 180°	....	2 Cr. 175°; 1 Br. 180°
		2	"	....	"	3 Cr. 180°	....	3 Cr. 180°
		3	2 O.K.; 1 Cr. 180°	....	5 O.K.; 1 Cr. 180°	1 O.K.; 2 Cr. 165, 175°	6 O.K.	3 Cr. 110, 115, 160°
		4	3 Cr. 180°	....	4 O.K.; 2 Br. 180°	3 Cr. 175, 180, 180°	"	3 Cr. 160, 180, 180°
		5	"	....	5 O.K.; 1 Br. 180°	"	"	3 Cr. 155, 180, 180°
		6	"	....	3 O.K.; 3 Br. 180°	3 Cr. 168, 180, 180°	"	3 Cr. 110, 140, 180°
		7	"	....	"	3 Cr. 128, 155, 175°	"	1 Br. 115°; 2 Cr. 108, 115°
		8	"	....	6 Br. 180°	3 Cr. 120, 150, 150°	"	1 Cr. 150°
	Transverse	3	....	....	3 Br. 70, 80, 80°	1 Cr. 72°; 1 Br. 94°	3 Br. 60, 60, 80°	2 Cr. 72, 73°
		4	....	....	"	2 Cr. 68, 75°	3 Br. 60, 80, 80°	2 Cr. 63, 75°
		5	....	....	3 Br. 60, 80, 80°	2 Cr. 68, 71°	"	1 Cr. 44°; 1 Br. 68°
		6	....	....	3 Br. 60, 60, 80°	1 Cr. 60°; 1 Br. 70°	3 Br. 60°	2 Br. 48, 52°
		7	....	....	3 Br. 60, 80, 80°	1 Cr. 57°; 1 Br. 59°	"	2 Br. 46, 51°
		8	....	....	"	2 Br. 54°	3 Br. 60, 60, 80°	2 Br. 39, 55°
IV	Longitudinal	1	3 F. 30°	....	3 F. 40, 40, 60°	2 F. 55°	....	2 F. 50, 69°
		2	3 F. 30, 30, 35°	....	3 F. 40, 60, 60°	2 F. 40°	....	2 F. 47, 60°
		3	3 F. 30°	....	3 F. 40°; 3 Br. 60°	2 F. 40, 51°	5 F. 100°; 1 Br. 120°	2 F. 56, 60°
		4	"	....	4 F. 40°; 2 Br. 60°	2 F. 40, 45°	2 F. 80°; 4 Br. 100°	2 F. 50, 55°
		5	"	....	"	2 F. 25, 35°	6 F. 80, 80, 100, 100, 100, 120°	2 F 55, 60°
		6	3 F. 30, 30, 35°	....	2 F. 40°; 4 Br. 60°	2 F. 45°	6 F. 60, 60, 80, 80, 80, 100°	2 F. 40, 54°
		7	3 F. 30°	....	3 F. 40°; 3 Br. 60°	2 F. 35, 45°	6 F. 60, 80, 80, 80, 80, 90°	2 F. 39, 66°
		8	3 F. 35, 35, 40°	....	"	2 F. 30, 35°	4 F. 80°. 2 Br. 100°	2 F. 45, 65°
	Transverse	3	....	....	3 F. 20, 20, 30°	2 F. 18, 19°	3 F. 20°	2 F. 15, 20°
		4	....	....	3 F. 20°	2 F. 20, 26°	3 F. 20, 30, 30°	2 F. 18, 19°
		5	....	....	"	2 F. 19, 24°	"	2 F. 13, 22°
		6	....	....	"	2 F. 20°	"	2 F. 11, 15°
		7	....	....	3 F. 20, 20, 30°	2 F. 15, 19°	3 F. 10, 20, 20°	2 F. 15°
		8	....	....	"	2 F. 16, 18°	3 F. 20°	2 F. 16, 18°

per inch at proportional limit and angle of twist per inch at break are plotted. The percentage of elongation, reduction of area and the shearing modulus of elasticity were also determined, but since they have no special significance they are not included in this preliminary report. Shearing strengths are reported in Figs. 16, 28 and 40.

DISCUSSION

As has previously been stated, the Joint Committee, while it has reviewed all of the test data in this investigation, will defer any extended discussion of the results and the drawing and publishing of any conclusions therefrom. From the study of the data the Joint Committee has realized the possibilities that exist for study not only of the effect of sulfur upon these steels but the influence upon the physical properties of, for example, the various kinds of heat treatment used and the directions in which the specimens are taken. A comparative study of the data presented will be of value.

Metallographic study of this material has been made. A determination of the oxygen content of the steels is also being made and both will be reported in the later complete publication.

Respectfully submitted on behalf of the Joint Committee,

GEORGE K. BURGESS,
Chairman.

C. L. WARWICK,
Secretary.

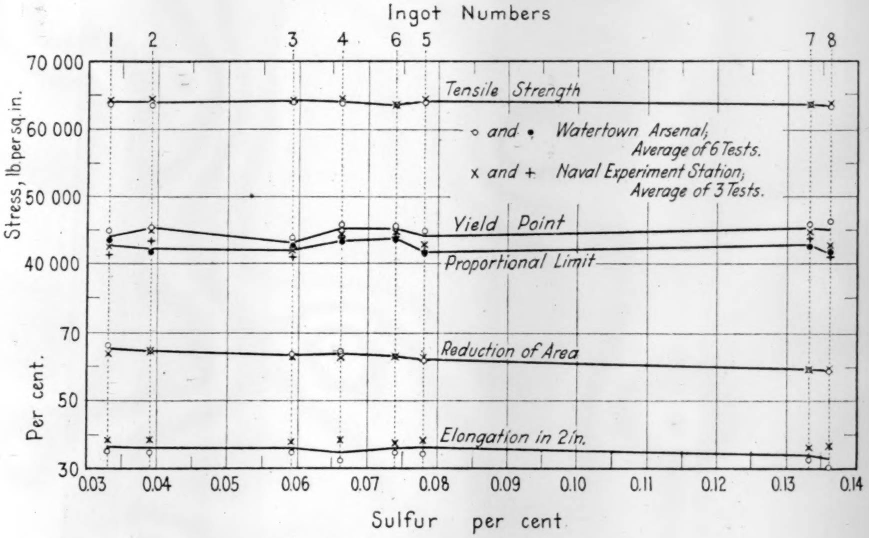

FIG. 3.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Natural Condition.

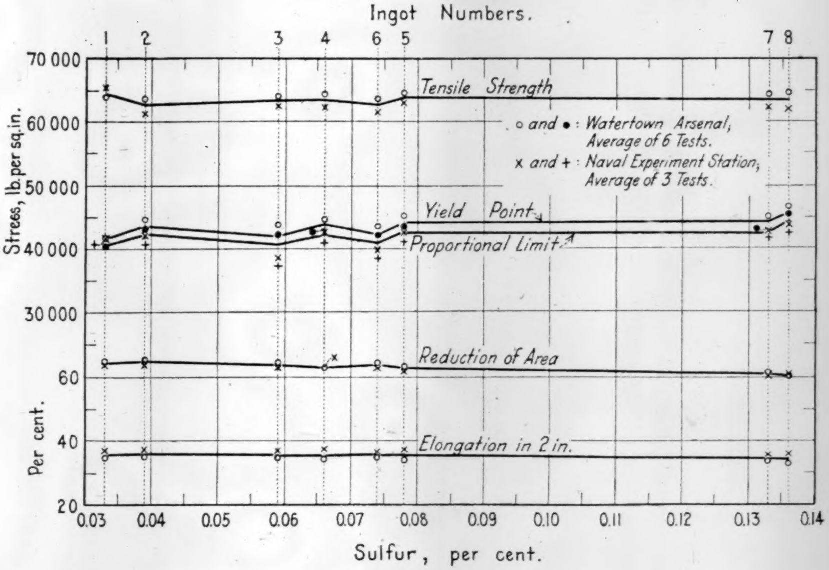

FIG. 4.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Normalized Condition.

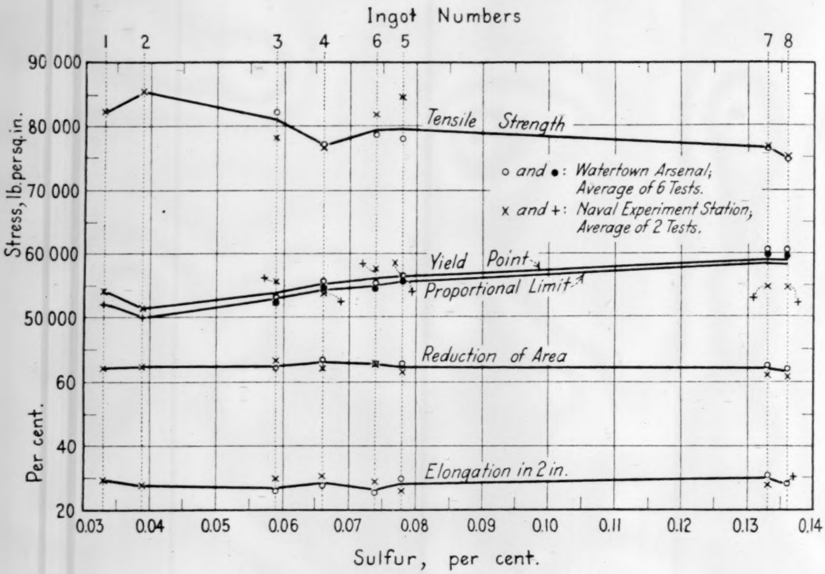

FIG. 5.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Quenched Condition.

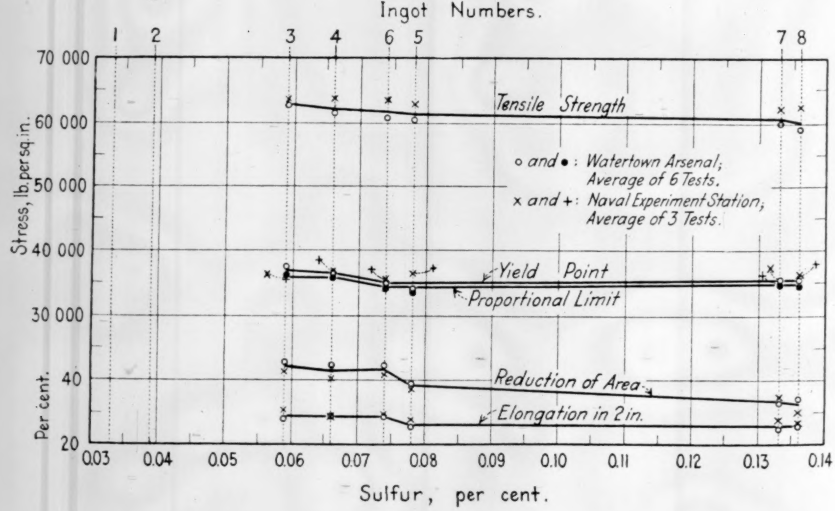

FIG. 6.—Tensile Properties of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group II. Natural Condition.

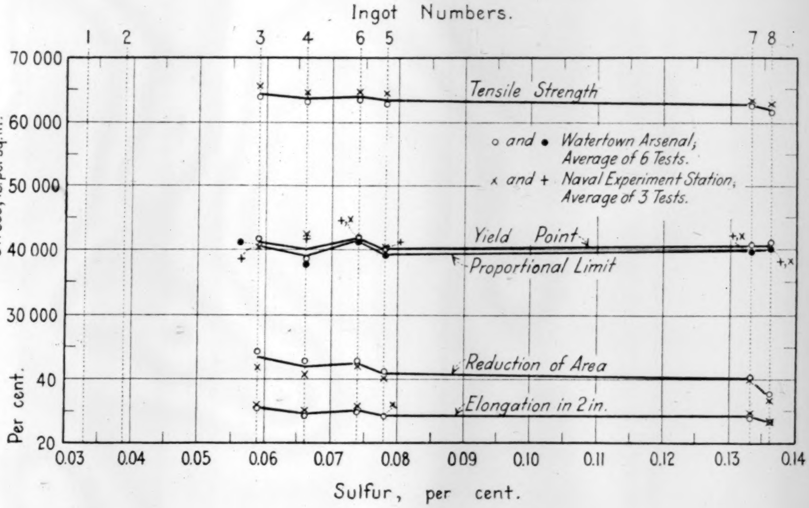

FIG. 7.—Tensile Properties of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group II. Normalized Condition.

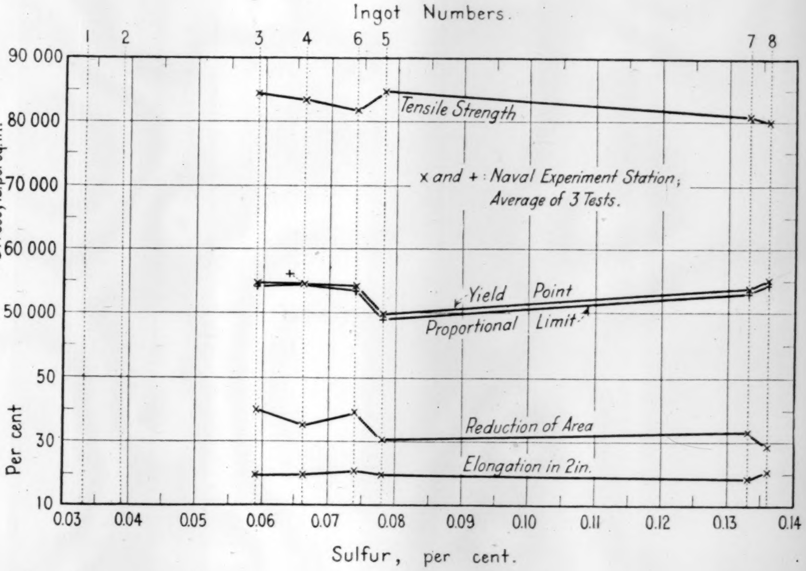

FIG. 8.—Tensile Properties of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group II. Quenched Condition.

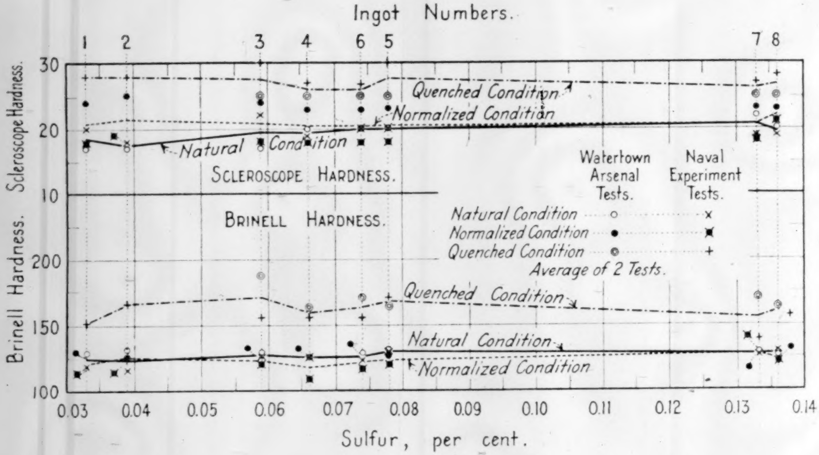

FIG. 9.—Brinell and Scleroscope Hardness Values of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Natural, Normalized and Quenched Conditions.

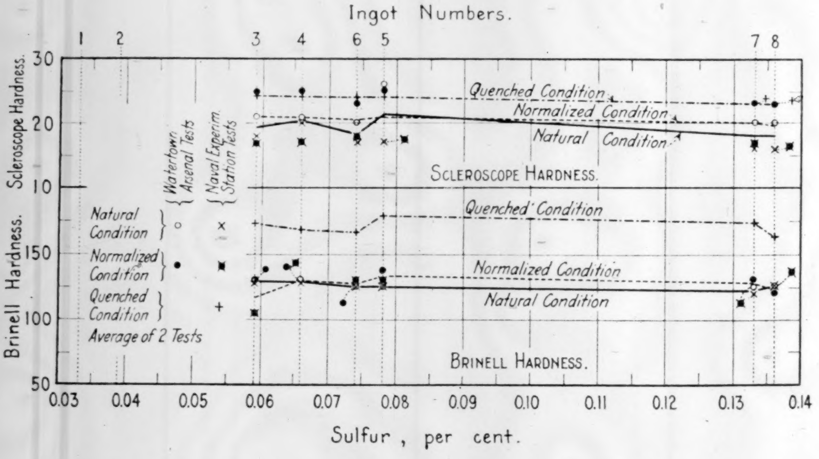

FIG. 10.—Brinell and Scleroscope Hardness Values of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group II. Natural, Normalized and Quenched Conditions.

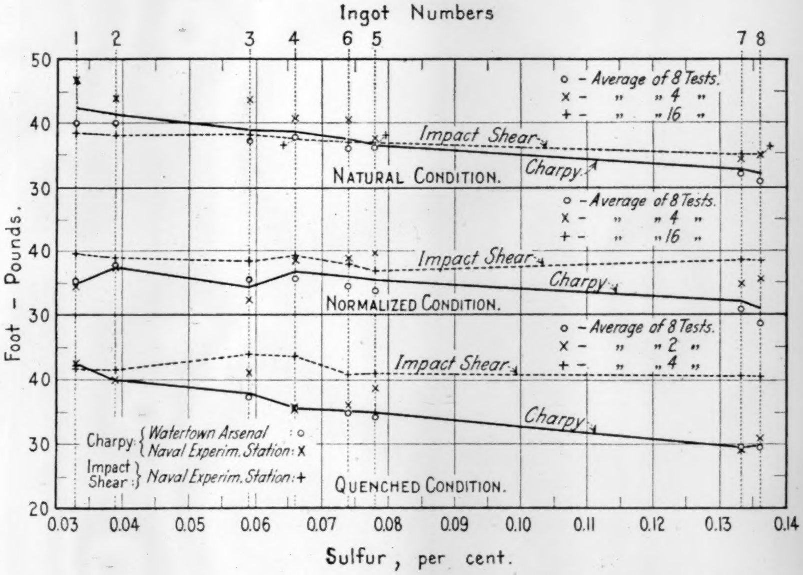

FIG. 11.—Impact Values of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Natural, Normalized and Quenched Conditions.

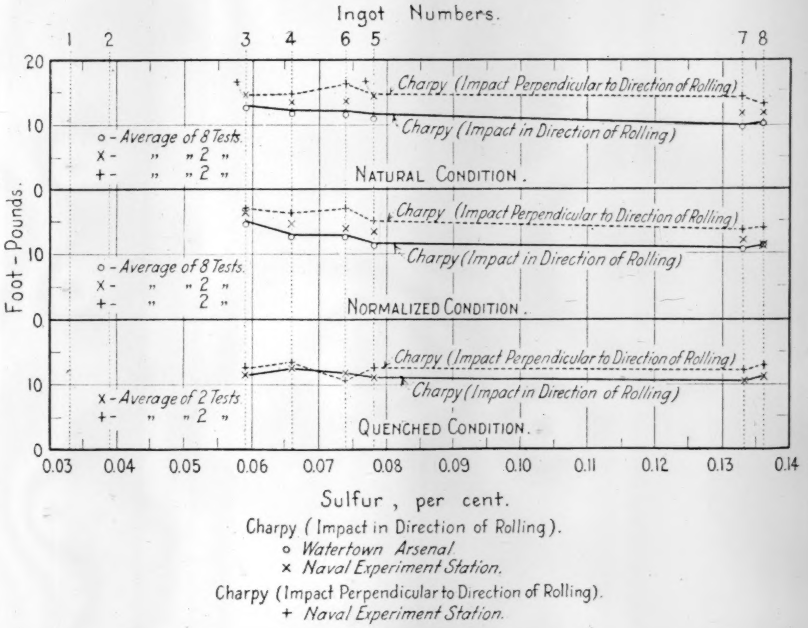

FIG. 12.—Impact Values of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group II. Natural, Normalized and Quenched Conditions.

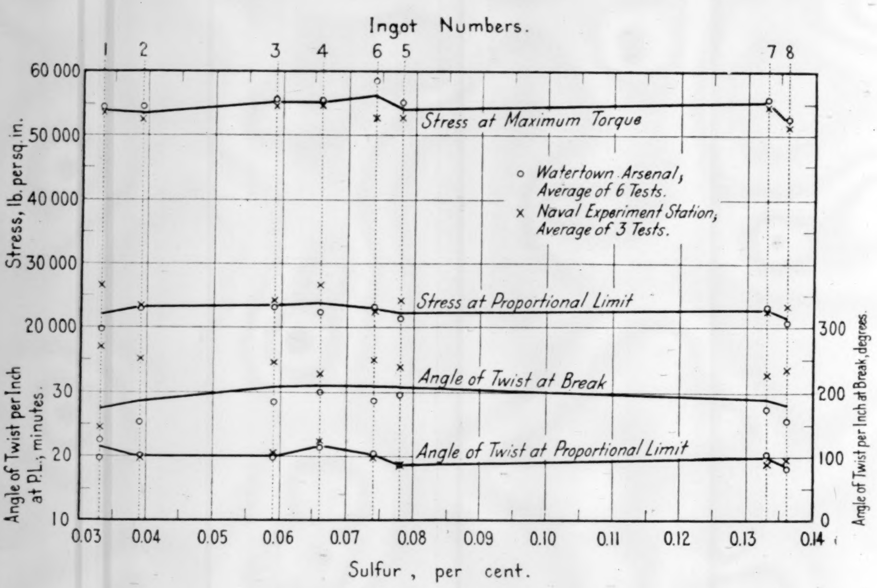

FIG. 13.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Natural Condition.

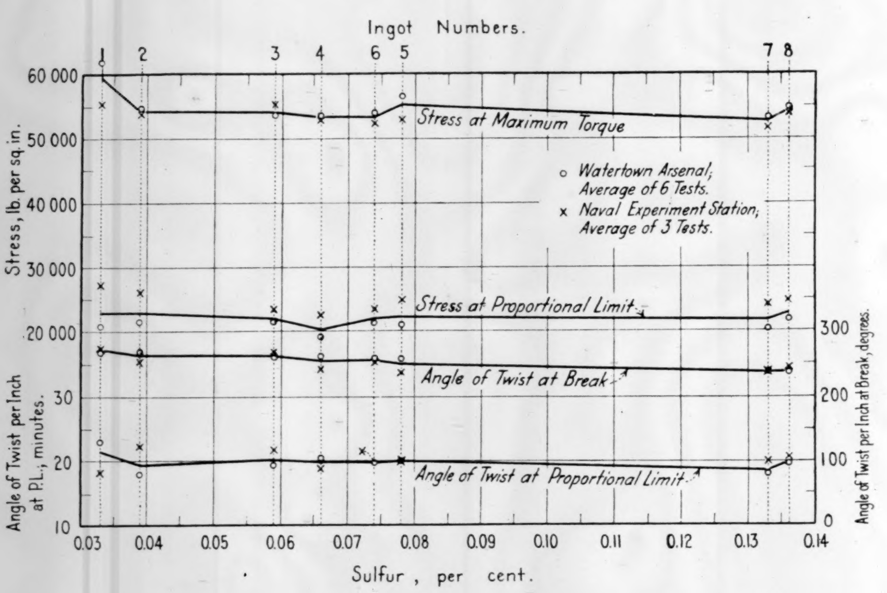

FIG. 14.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Normalized Condition.

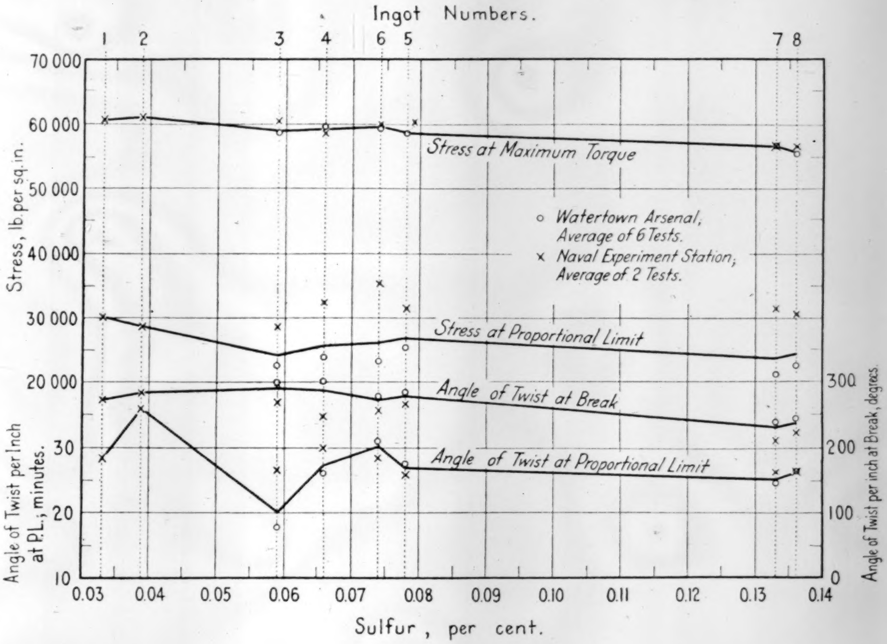

FIG. 15.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group II. Quenched Condition.

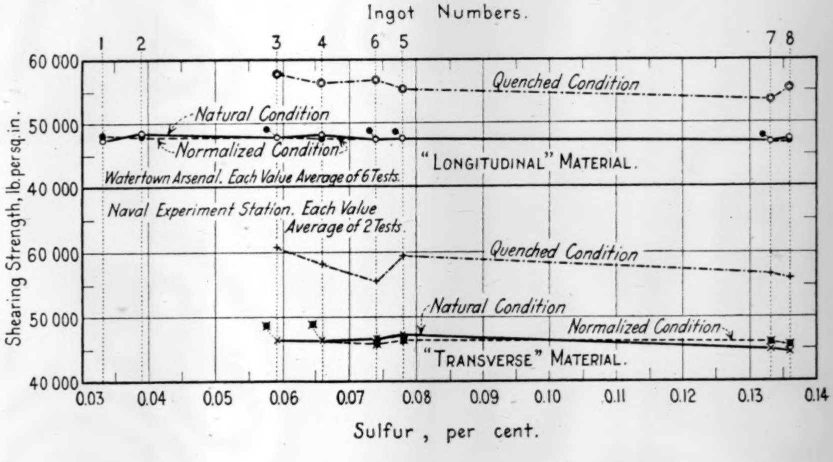

FIG. 16.—Shearing Strengths of Material, Group II. Natural, Normalized and Quenched Conditions.

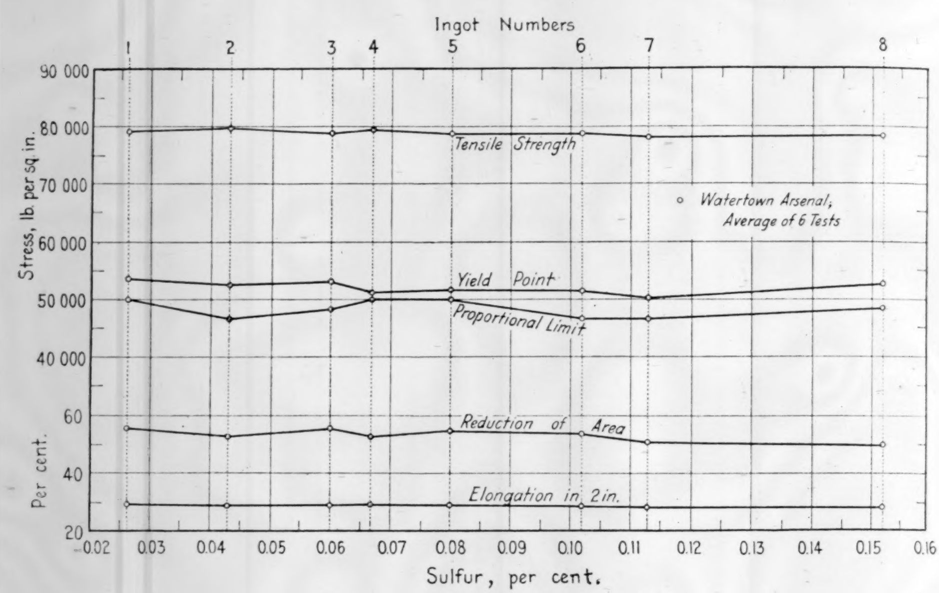

FIG. 17.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group III. Natural Condition.

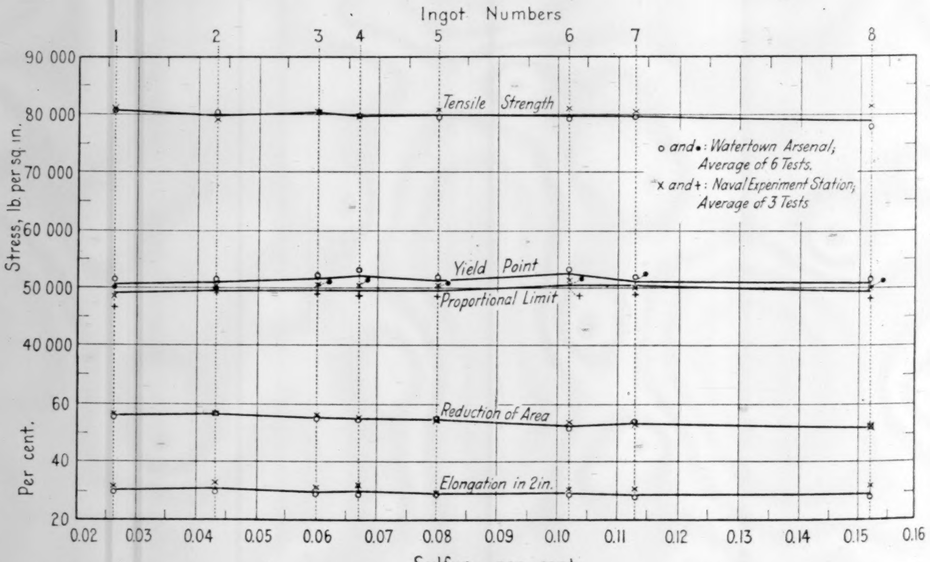

FIG. 18.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group III. Normalized Condition.

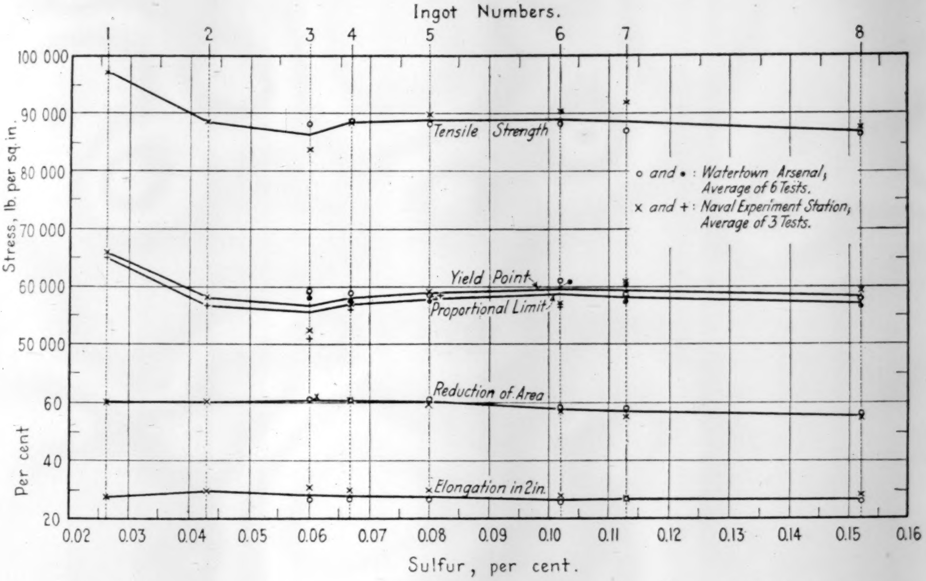

FIG. 19.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group III. Quenched-and-Drawn Condition.

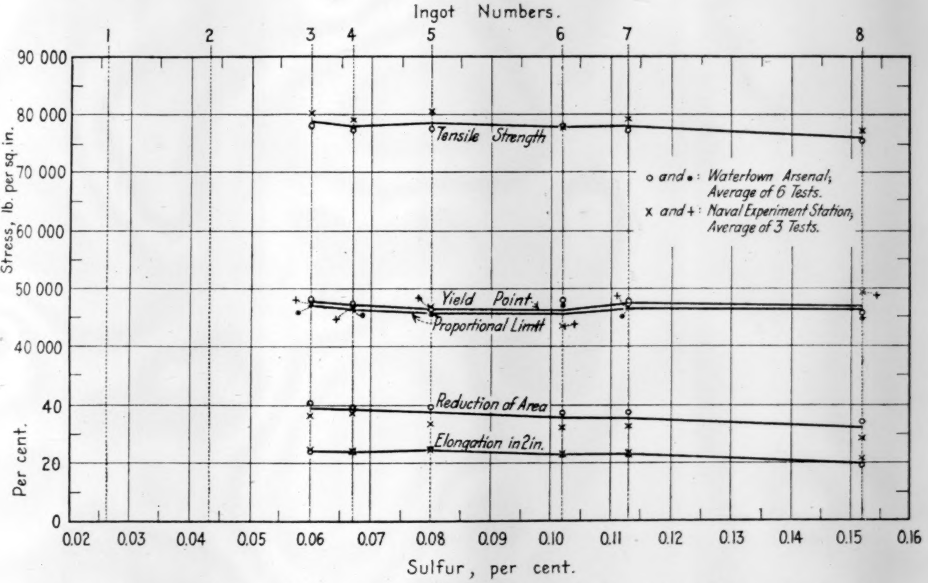

FIG. 20.—Tensile Properties of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group III. Normalized Condition.

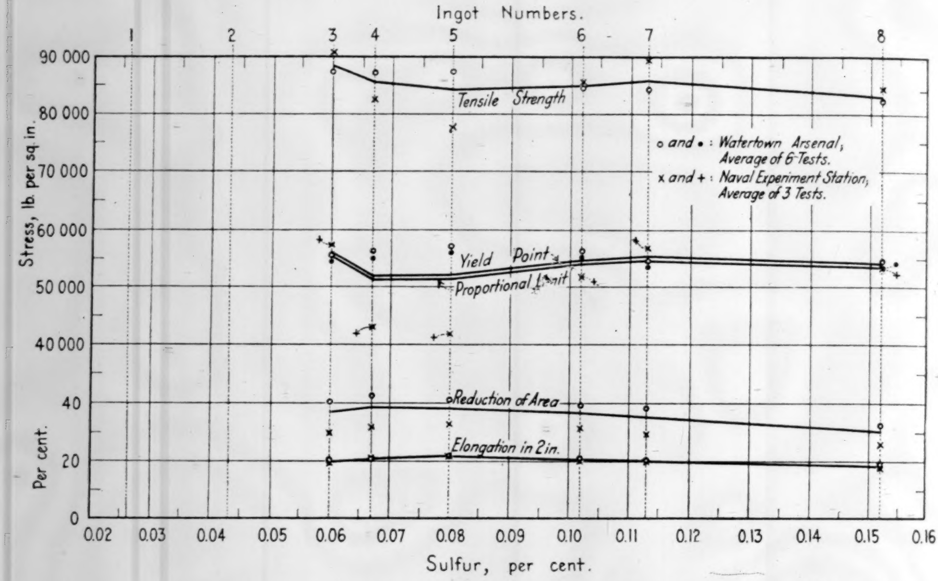

FIG. 21.—Tensile Properties of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group III. Quenched-and-Drawn Condition.

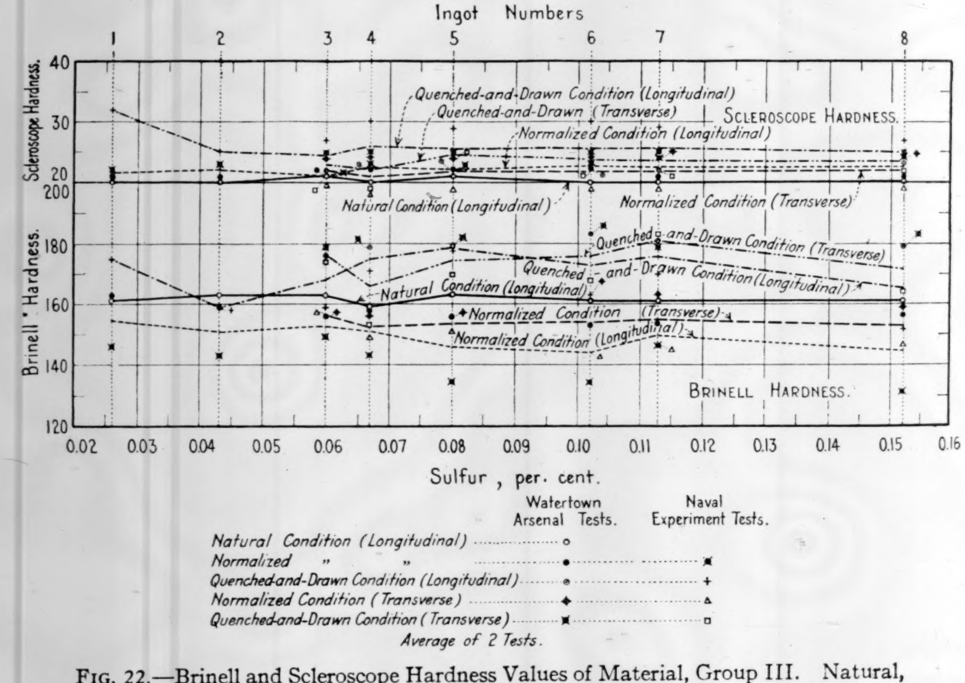

FIG. 22.—Brinell and Scleroscope Hardness Values of Material, Group III. Natural, Normalized and Quenched-and-Drawn Conditions.

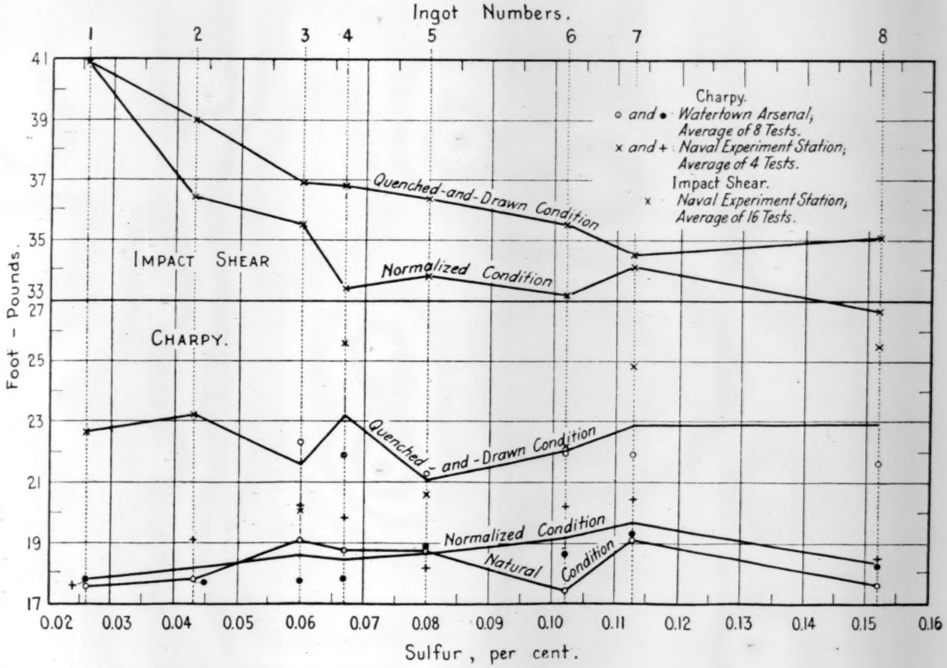

FIG. 23.—Impact Values of Specimens with Longitudinal Axes in Direction of Rolling, Group III. Natural, Normalized and Quenched-and-Drawn Conditions.

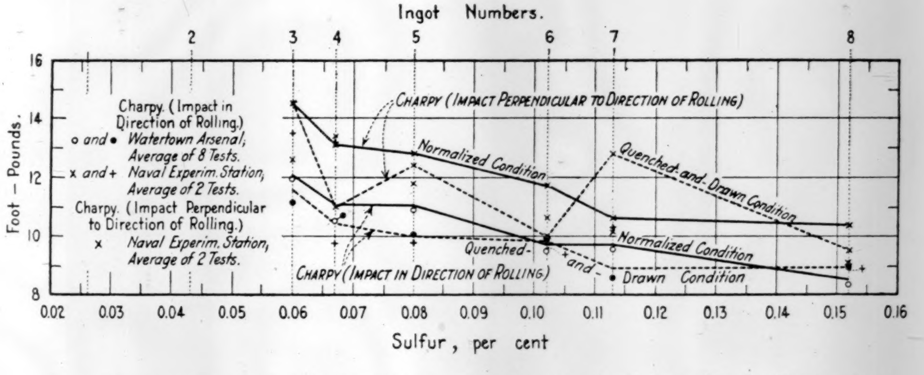

FIG. 24.—Impact Values of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group III. Normalized and Quenched-and-Drawn Conditions.

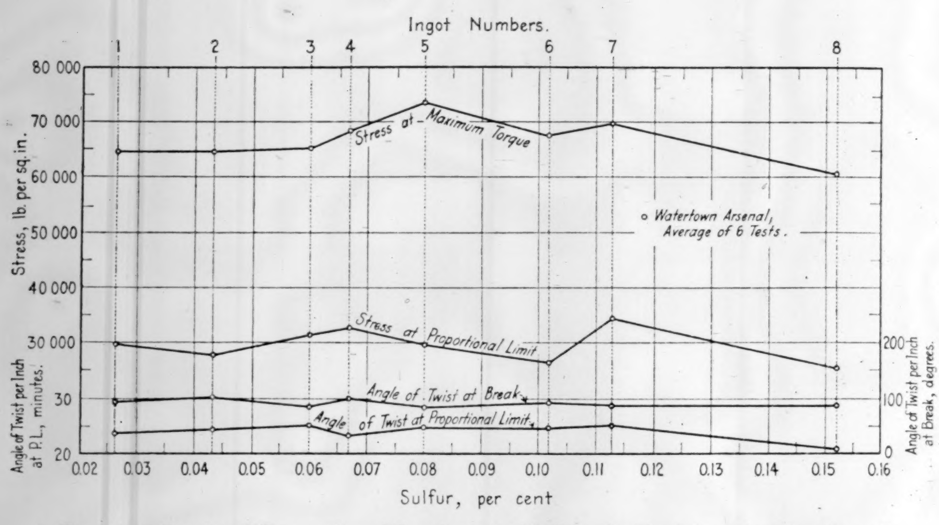

FIG. 25.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group III. Natural Condition.

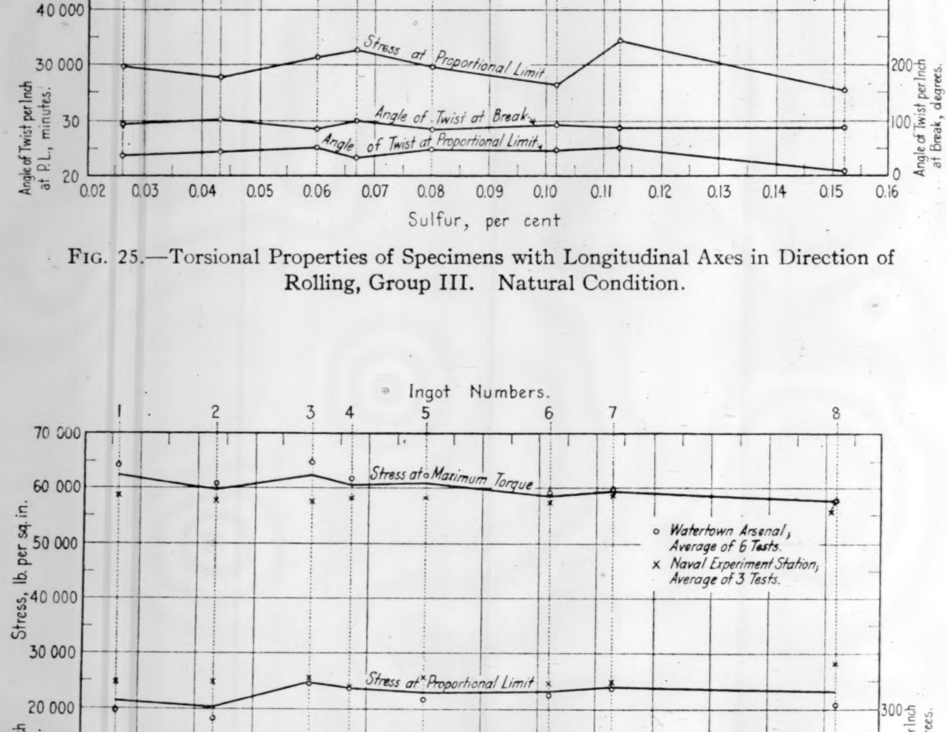

FIG. 26.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group III. Normalized Condition.

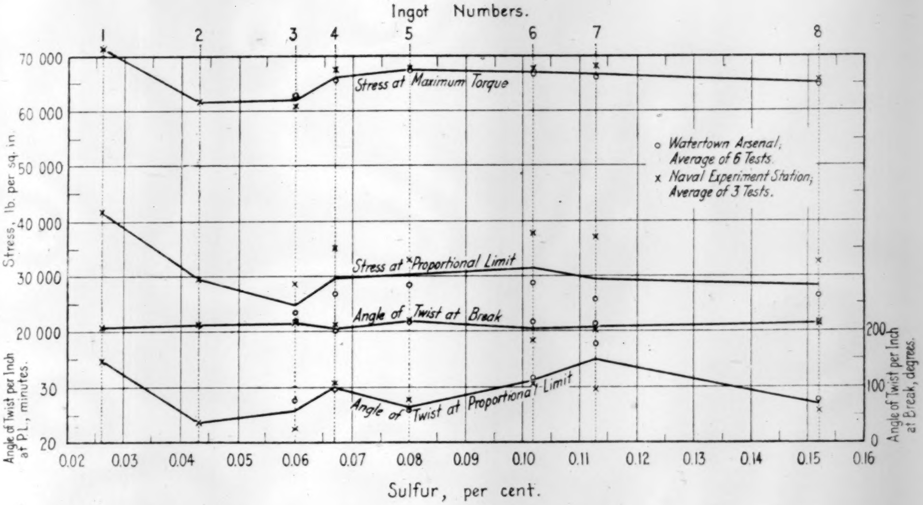

FIG 27.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group III. Quenched-and-Drawn Condition.

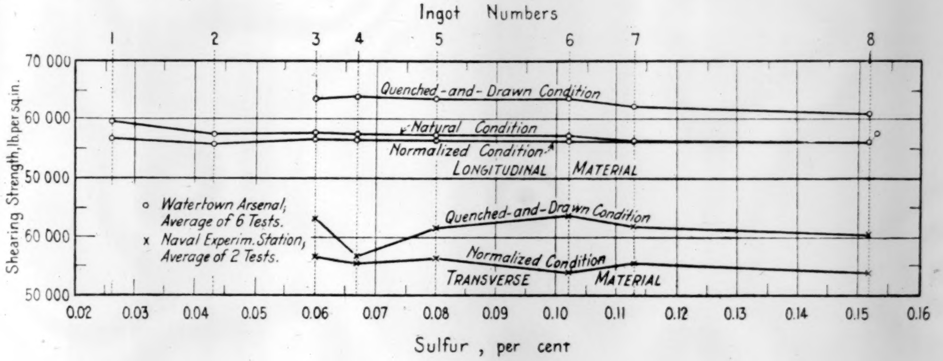

FIG. 28.—Shearing Strengths of Material, Group III. Natural, Normalized and Quenched-and-Drawn Condition.

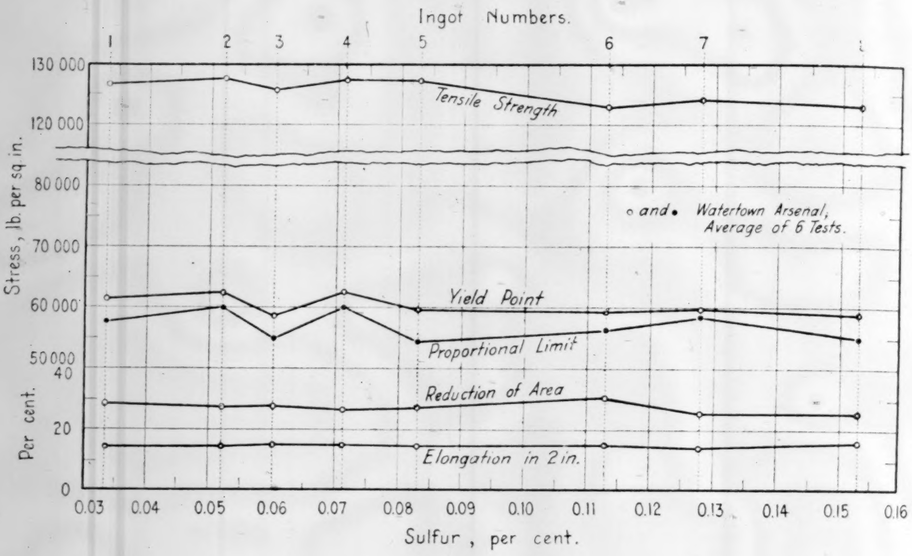

FIG. 29.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group IV. Natural Condition.

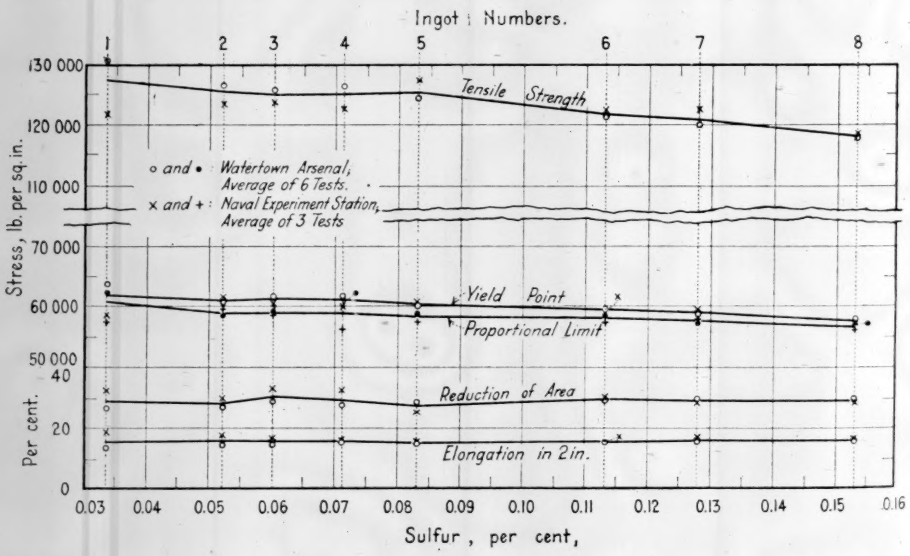

FIG. 30.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group IV. Normalized Condition.

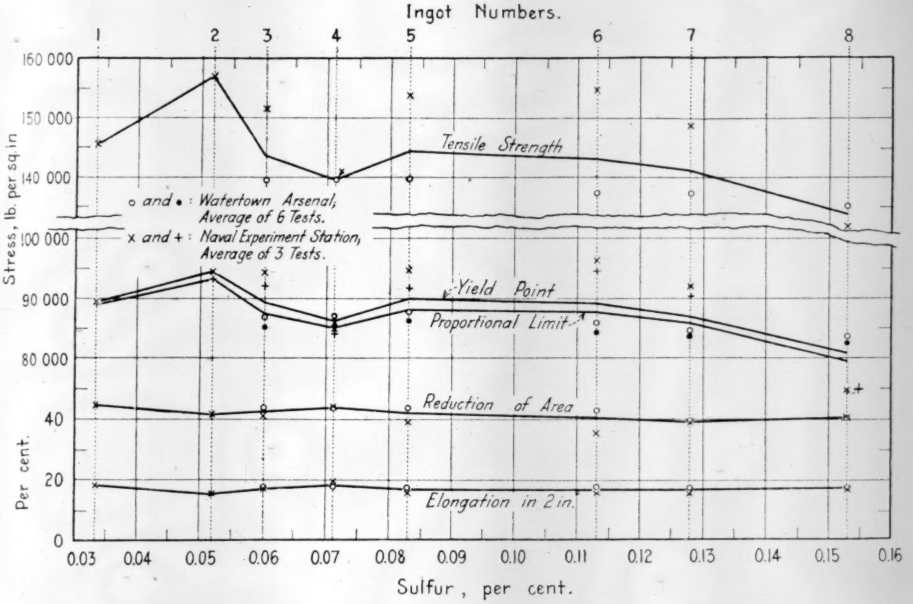

FIG. 31.—Tensile Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group IV. Quenched-and-Drawn Condition.

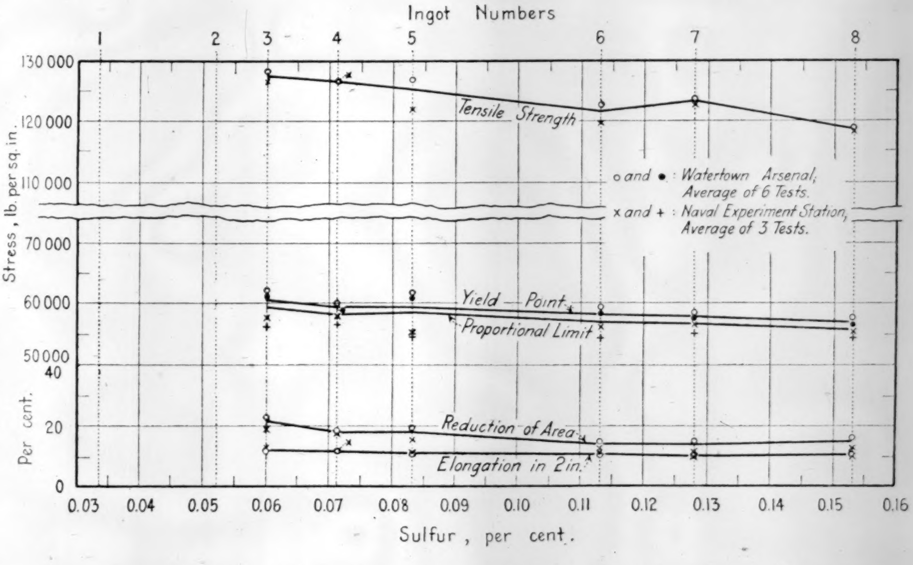

FIG. 32.—Tensile Properties of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group IV. Normalized Condition.

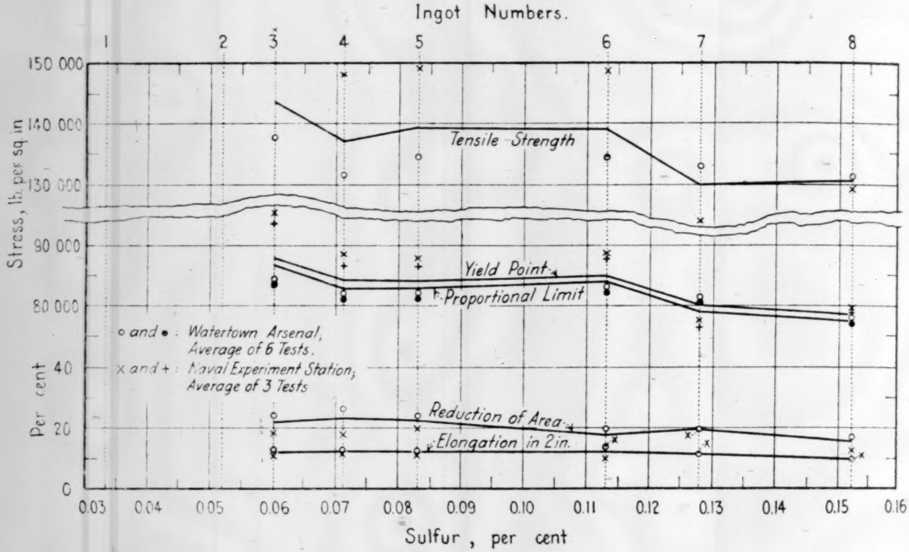

FIG. 33.—Tensile Properties of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group IV. Quenched-and-Drawn Condition.

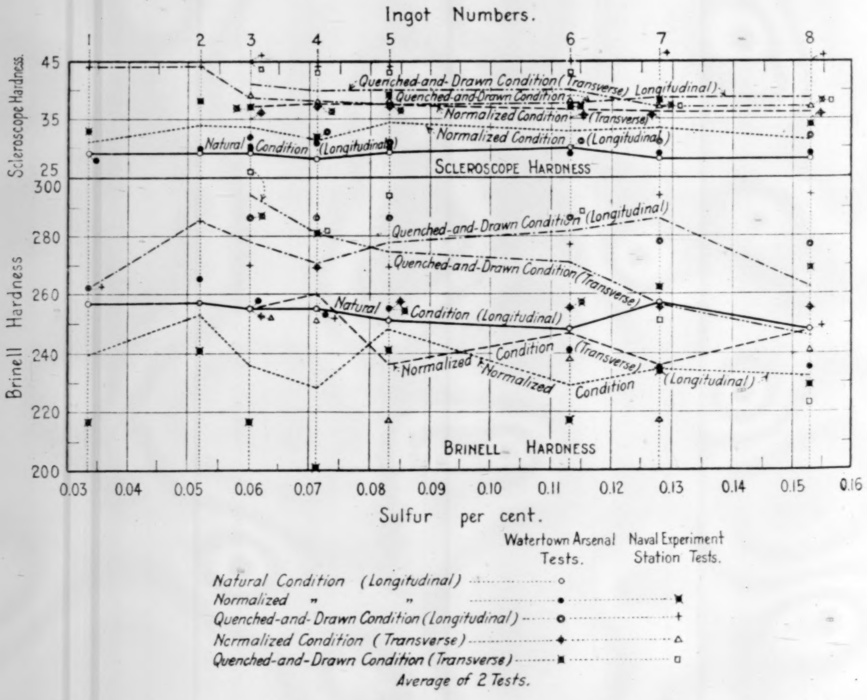

FIG 34.—Brinell and Scleroscope Hardness Values of Material, Group IV. Natural, Normalized and Quenched-and-Drawn Conditions

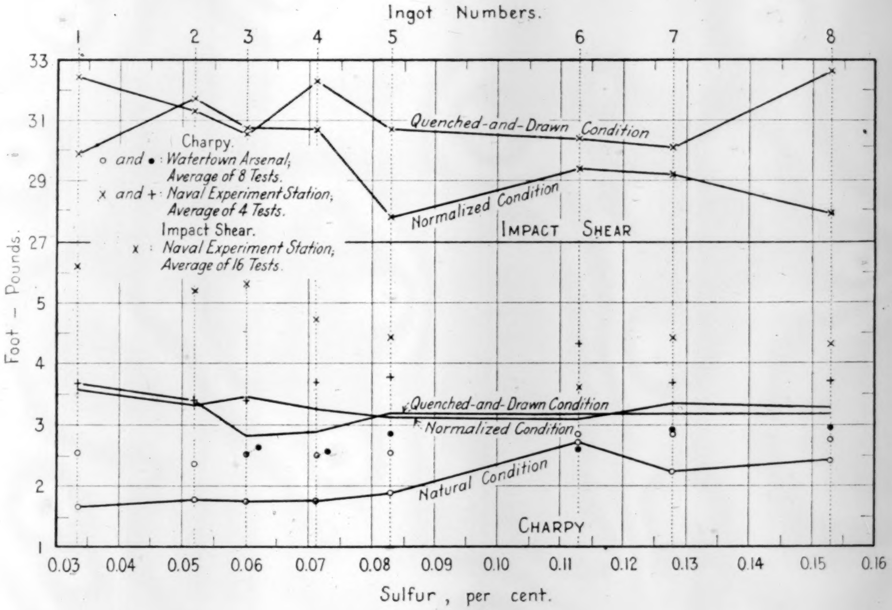

FIG. 35.—Impact Values of Specimens with Longitudinal Axes in Direction of Rolling, Group IV. Natural, Normalized and Quenched-and-Drawn Conditions.

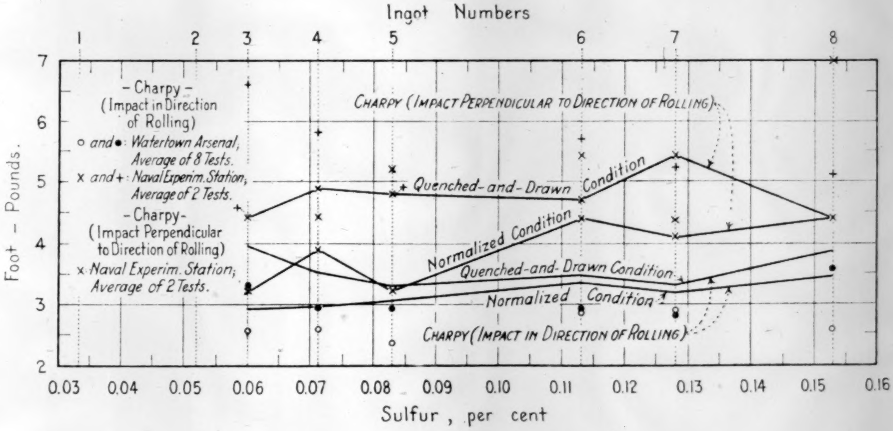

FIG. 36.—Impact Values of Specimens with Longitudinal Axes Perpendicular to Direction of Rolling, Group IV. Normalized and Quenched-and-Drawn Conditions.

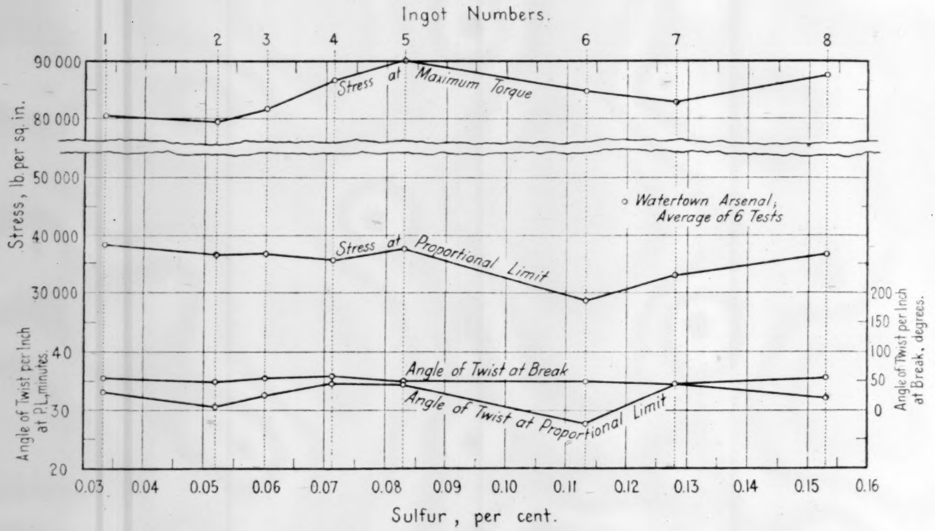

FIG. 37.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group IV. Natural Condition.

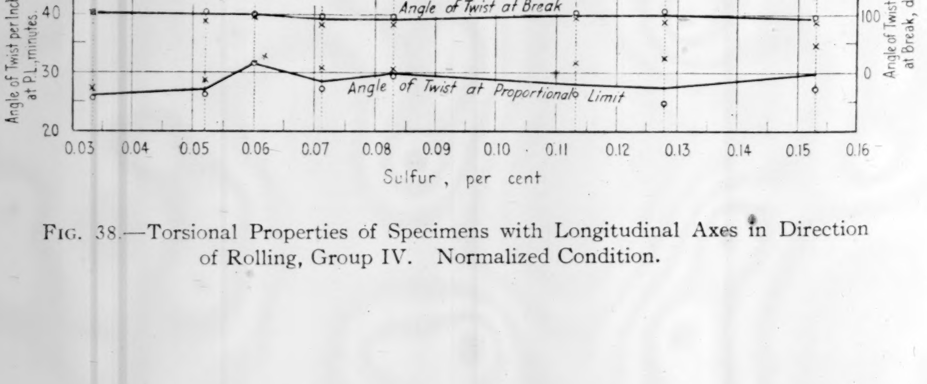

FIG. 38.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group IV. Normalized Condition.

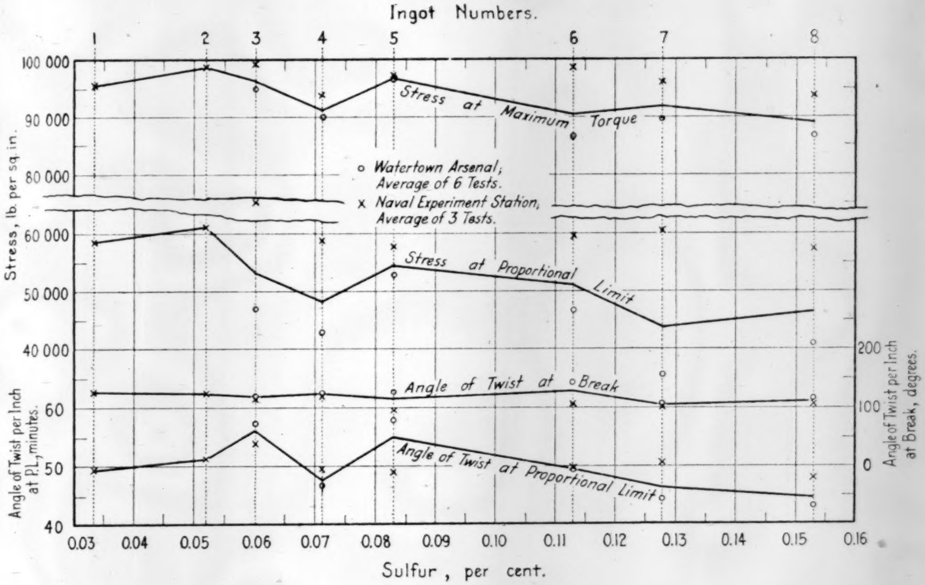

FIG. 39.—Torsional Properties of Specimens with Longitudinal Axes in Direction of Rolling, Group IV. Quenched-and-Drawn Condition.

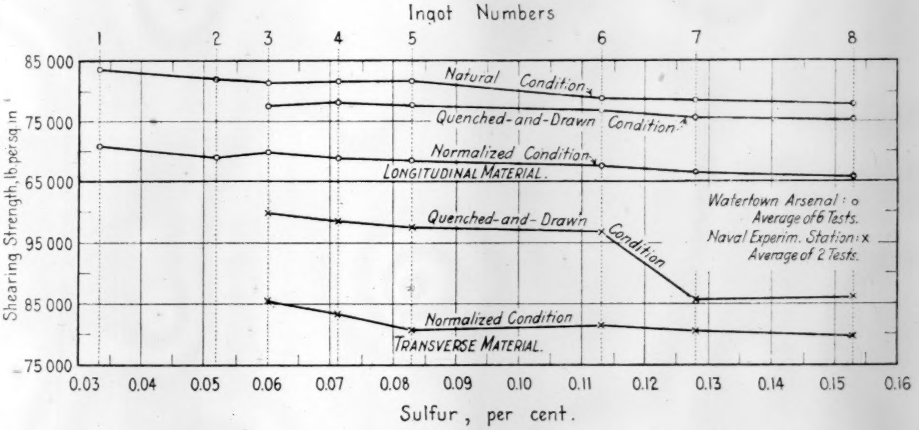

FIG. 40.—Shearing Strengths of Material, Group IV. Natural, Normalized and Quenched-and-Drawn Conditions.

APPENDIX

ORGANIZATION OF THE JOINT COMMITTEE ON INVESTIGATION OF PHOSPHORUS AND SULFUR IN STEEL

The Joint Committee on Investigation of Phosphorus and Sulfur in Steel was organized in November, 1919, under the joint initiative of the American Society for Testing Materials, the U. S. Bureau of Standards and the then existing U. S. Railroad Administration. The following organizations are now represented on the Joint Committee:

ORGANIZATIONS	REPRESENTED BY
U. S. Bureau of Standards	George K. Burgess, *Chairman* H. L. Whittemore
American Society for Testing Materials	Robert W. Hunt Co. (J. F. Davis) T. D. Lynch C. L. Warwick, *Secretary (ex-officio)*
American Railway Association, Mechanical Division	F. M. Waring H. E. Smith
U. S. War Department	F. C. Langenberg
U. S. Navy Department	D. J. McAdam, Jr.
Society of Automotive Engineers	F. P. Gilligan
Society of Naval Architects and Marine Engineers	F. W. Wood
National Research Council, Engineering Division	John H. Hall
Association of American Steel Manufacturers	E. F. Kenney J. J. Shuman
Steel Founders Society of America	J. E. McCauley
American Foundrymen's Association	R. A. Bull

The complete investigation planned by the Joint Committee includes a study of the effect of sulfur and phosphorus on steel in which the sulfur is residual (Series A) and steel in which the sulfur may be added during the later stages of manufacture before reaching the mold, in the form of additions to be determined (Series B). By "residual" sulfur is meant sulfur present in the steel through its presence in fuel or in pig or scrap.

The material in Series A covers six groups as follows:

GROUP No.	MATERIAL	CARBON, PER CENT	MANGANESE, PER CENT	PHOSPHORUS, PER CENT	SULFUR, PER CENT
I	Rivet Steel, Tubes, etc.	0.06 – 0.12	0.35 – 0.40	0.02 – 0.03	0.03 – 0.04
				0.04 – 0.05	0.05 – 0.06
				0.06 – 0.07	0.07 – 0.08

GROUP No.	MATERIAL	CARBON, PER CENT	MANGANESE, PER CENT	PHOSPHORUS, PER CENT	SULFUR, PER CENT
II	Plates and Structural Shapes, including Boiler Plate	0.16 – 0.22	0.35 – 0.40	0.03 – 0.04	0.03 – 0.04
				0.05 – 0.06	0.05 – 0.06
				0.07 – 0.08	0.07 – 0.08
III	Forgings, such as Car Axles, treated and untreated	0.45 – 0.55	0.50 – 0.60	0.03 – 0.04	0.03 – 0.04
				0.05 – 0.06	0.05 – 0.06
				0.07 – 0.08	0.07 – 0.08
IV	Wheel, Tire and Rail Steel	0.65 – 0.75	0.60 – 0.70	0.03 – 0.04	0.03 – 0.04
				0.05 – 0.06	0.05 – 0.06
				0.07 – 0.08	0.07 – 0.08
V	Spring Steels	0.95 – 1.05	0.35 – 0.45	0.02 – 0.03	0.03 – 0.04
				0.04 – 0.05	0.05 – 0.06
				0.06 – 0.07	0.07 – 0.08
VI	Castings	Compositions to be considered later.			

In all groups, when determining the effect of sulfur, the sulfur content ranges in general from 0.03 to 0.08 per cent, with phosphorus and other elements normal and as nearly constant as possible. When determining the effect of phosphorus, the phosphorus content will range in general as specified, with sulfur and other elements normal and as nearly constant as possible.

Material secured under Series B is classed in the same six groups.

The groups in Series A cover practically all of the usual ranges of carbon, and of the materials covered in A.S.T.M. Steel Specifications. The ranges in phosphorus and sulfur extend up to 0.08 per cent, which is considered to be practicable for present commercial practice. The Committee considers it desirable to investigate first the material in this series, but the desirability of studying the problem from a more general point of view has been recognized by providing for the tests in Series B covering higher limits of these impurities.

The Joint Committee has considered the study of the effect of sulfur to be more urgent than the study of the effect of phosphorus and consequently is proceeding with this part of the investigation first.

The investigation is being conducted on the "unanimous consent" basis; that is, every step of the program must be acceptable to all parties.

The work of the Committee is divided among the following six committees:

Committee on Manufacture

G. K. Burgess, *Chairman*
H. E. Smith
E. F. Kenney
F. W. Wood

Committee on Service Tests

F. P. Gilligan, *Chairman*
F. M. Waring
H. L. Whittemore

Committee on Tests

F. C. Langenberg, *Chairman*
J. F. Davis
F. P. Gilligan
D. J. McAdam, Jr.
E. F. Kenney

Committee on Finance

C. L. Warwick, *Chairman*
T. D. Lynch
J. E. McCauley
H. E. Smith

Committee on Statistics

H. L. Whittemore, *Chairman*
J. J. Shuman
F. M. Waring
J. H. Hall
R. A. Bull

Committee on Publicity

G. K. Burgess, *Chairman*
C. L. Warwick

The manufacture of all materials for the investigation is under the direct supervision of the Committee on Manufacture. The laboratory tests are made under the direction of the Committee on Tests, the present plan being for tests to be made in duplicate at the laboratories of the Watertown Arsenal and the U. S. Naval Engineering Experiment Station, check tests where necessary being made at the U. S. Bureau of Standards.

REPORT OF COMMITTEE A-3
ON
CAST IRON

A progress report on the activities of Committee A-3 is presented herewith, covering the status of the pending tentative specifications. These cover the subjects of chilled cast-iron car wheels, pig iron and "high-test" cast iron.

Time is being marked on the car-wheel problem while a series of tests is being conducted by the railroads, the outcome of which may have a bearing on the tentative specifications of the Society. As this is the first set of cast-iron specifications in which the analysis of the castings is made a definite requirement, the outcome of this radical change in judging castings will be watched with great interest.

During the past year, the adaptability of the tentative specifications for pig iron for the steel and the malleable foundry, in addition to the iron foundry proper, have been studied and suitable changes and rearrangements are being made which appear to cover the situation properly. In spite of the experience of foundrymen to the contrary, there is a persistent call from consumers of castings for definite compositions for given lines of castings. To respond to this call for information desired by the consumer—information every modern foundryman should have and guide his procedure with—the committee has requested the Sub-Committee on General Castings to take up this matter with a view of constructing tables of analysis ranges for important lines of foundry product. These analysis ranges, however, are to be given as "recommended practice" and are not intended for actual specification. In this way, the consumer of the foundry product will get the information he wants; the furnaceman will be guided in the production of his pig irons to prepare for analysis ranges which are more closely standardized and have less of "freak" requirements made by inexperienced metallurgists; and the foundryman will not be bound by chemical requirements he knows will not work out well with his particular regional supplies of melting stock. It is intended to call attention to this work of the sub-committee on standard ranges of analyses of castings in a preamble to the pig-iron specifications, so that the specifications themselves are not burdened with such data. It may be stated parenthetically that the specifications for pig iron, as promulgated by the Society, are in reality only a guide to the systematic and modern ways of purchasing this material, and embrace methods for sampling and analysis which are very simple for ordinary routine delivery. However, in case of dispute between producer and consumer, these pig-iron specifications are used in conjunction with the Society's Standard Methods of Sampling and Analysis of Pig and Cast Iron, and then the provisions of the joint requirements become very definite and effective.

During the coming year it is hoped to crystallize the ideas involved into definite propositions to be laid before the Society in the shape of Specifications and Schemes of Recommended Practice, for such action as may prove desirable.

Finally, the matter of the Tentative Specifications for High-Test Gray-Iron Castings has been under advisements during the year, and an important modification is under consideration. Visitors from foreign countries going through our foundries rarely see the Society "Arbitration Bar" in use, and where they do they cannot understand why the bars are seldom of the exact diameter as cast and tested. We, ourselves, are prone to forget that no "arbitration" bar is used unless there is a dispute, or the probability of a controversy. Foundrymen are apt to stick to their own bars in order not to lose the experience had with them. It is only when castings for very definite service demands are to be made that the subject of providing a safe and reliable test comes in. Then, it will be found, the Society's Arbitration Bar is specified and used, as it has been found to be more free from objections than any other bar. "More free" is used advisedly, for there is only one objection that the years of practice with this bar has shown, and that is its comparative shortness. The bar, broken transversely on supports 12 in. apart, has proved insufficiently sensitive to what might be called the elasticity of the metal. The question of lengthening the Standard Arbitration Bar is, therefore, under consideration; but this has been held in abeyance pending the outcome of the movement for an international arbitration bar, now revived. At the coming September meeting of the French, Belgian, British and American foundrymen, in Paris, this subject will be considered, and the committee will be represented by its officers in conjunction with a special committee from the American Foundrymen's Association. The originally proposed "International Arbitration Bar" of the Brussels Meeting of December 5, 1913, a bar 1.2 in. in diameter and broken transversely on supports 18 in. apart, will probably be found most acceptable. It has been favorably acted upon by the British Committee as one of a set of three bars recommended for English foundry practice. This would fit well with the American desire for a lengthened Arbitration Bar, the 1.2 in. diameter being so close to our 1.25 in. as to make but little difference.

The question of "over" and "under" sized bars is to be cared for by the important modification added as an appendix to the Tentative Specifications for High-Test Gray-Iron Castings. Factors have been calculated by which the test results will be corrected for hundreths of an inch increase or decrease in diameter up to 0.05 in. Bars that vary beyond this range should not be used for the transverse test. This will overcome the objection to varying diameters for which machining to standard size has been practiced abroad and recommended as standard practice there. It will obviate added expense for the test and the change in character of the metal under maximum fiber stress to an uncertainty dependent upon the depth of the cut.

Respectfully submitted on behalf of the committee,

RICHARD MOLDENKE,
Chairman.

G. C. DAVIES,
Secretary.

DISCUSSION

Mr. Smith

MR. H. E. SMITH.[1]—Possibly it is not quite a matter for the present report, but I would like to emphasize two points in the practical testing and inspection of castings; one is in chemical analysis and the other in physical testing. We have recently had discussions with quite a large producer of a certain line of castings and found that in the course of determining the sulfur by the quick method, he was deceiving himself as to the composition of the metal; errors in sulfur content of easily 0.02 per cent were made. The necessity for checking the quick method by the absolute method is very important and should not be lost sight of.

Another thing already mentioned is measuring the arbitration bars and correcting for variation from the 1.25-in. diameter. The inspection of the table of corrections will show that very large differences are made by even a few hundredths of an inch because the strength varies with the cube of the diameter.

Mr. Moldenke

MR. RICHARD MOLDENKE[2] (*Chairman, Committee A-3*).—I think Mr. Smith is right, but that he was lucky to be off only 0.02 per cent in sulfur. I have known errors of 0.05 per cent. With copper present, the volumetric method would be entirely off. I brought out in our report that in ordinary routine, when everything runs nicely, the pig iron specifications can be checked up with the rapid method of analysis, but when close to limits the exact and longer methods of analysis should be used.

Referring to the remarks about the arbitration bar: Take a bar about 0.04 or 0.05 in. oversize or undersize; it makes a difference of possibly 10 per cent in the result, and as a consequence we have come to the conclusion in Committee A-3 that a table should be added to the specifications which will show at a glance by what factor results must be multiplied to get the true result. In England they turn the bar to standard size and think they have a correct bar. Yet this is not really the case, because if you take away the skin and some of the strong material close to it, the bar is much weaker. Hence, the bars ought to be allowed to vary only a few hundredths of an inch either way; otherwise, it is best to throw them out.

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[1] Engineer of Tests, New York Central Lines.

[2] Consulting Metallurgist, Watchung, N. J.

MR. ROBERT JOB.[1]—I would like to ask Mr. Smith whether the determinations in sulfur were made after annealing the borings. **Mr. Job**

MR. SMITH.—Of course the wheel itself was annealed by the usual process of manufacture, that is the hot wheel put in the pit; but the borings or the small piece broken out were not treated in any way before analysis. **Mr. Smith**

MR. JOB.—I raised the question because in the determination of sulfur in cast iron or in pig iron by the volumetric method, it is our invariable practice to weigh out the borings into a crucible, and after covering the latter, to heat in the full flame of a bunsen burner for half an hour. If this precaution is not taken, the percentage of sulfur found by the volumetric process may be far below the percentage actually present. This simple annealing generally brings the result of the volumetric determination in close agreement with the gravimetric result. In addition to increasing the accuracy of the analysis, annealing generally aids decidedly in the ease with which the borings are gotten into solution. **Mr. Job**

MR. J. T. MACKENZIE.[2]—The reason the sulfur escapes the absorbent is that it is evolved as methyl sulfide by reaction with the iron carbide. Annealing, by decomposing the pearlite into ferrite and graphite, leaves less carbide to react and therefore the recovery is improved. **Mr. MacKenzie**

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[1] Vice-President, Milton Hersey Co., Ltd., Montreal, Canada.

[2] Chief Chemist, American Cast Iron Pipe Co., Birmingham, Ala.

REPORT OF COMMITTEE A-4

ON

HEAT TREATMENT OF IRON AND STEEL

Committee A-4 has held three meetings during the past year as follows: At Atlantic City on June 27, 1922; at Detroit on October 6, 1922; and at Philadelphia on March 10, 1923.

The following new members were elected during the year:

Baldwin Locomotive Works, Philadelphia, Pa., Mr. R. P. Johnson, representative;

S. G. Taylor Chain Co., Chicago, Ill., E. W. Taylor, representative;

American Foundrymen's Association, H. A. Neel, representative;

Timken Roller Bearing Co., Canton, Ohio, Mr. E. W. Ehn, representative.

The title of Sub-Committee II has been changed to Sub-Committee on Heat Treatment of Iron and Steel Castings. It is planned to expand the membership of this committee with the view of covering the heat treatment of gray iron and malleable iron. Sub-Committee V under the able chairmanship of Mr. Aston reports considerable progress in its investigation to determine the desirability of annealing iron chain at intervals. Mr. G. B. Waterhouse has accepted the chairmanship of Sub-Committee VI on Nomenclature and Definitions and has consented to serve as the representative of Committee A-4 on Committee E-8 on Nomenclature and Definitions. Several other changes have been made in the chairmanships of the sub-committees.

Mr. R. M. Bird was appointed special representative on a joint committee consisting of representatives of Committee A-4 of the American Society for Testing Materials, the Standards Committee of the American Society for Steel Treating, and the Standards Committee of the Society of Automotive Engineers for the consideration of uniform definitions of terms relating to heat treatment.

It is recommended that the Recommended Practice for Heat Treatment of Carbon-Steel Castings (A 36 - 22 T) remain tentative for another year.

This report has been submitted to the letter ballot of the committee, which consists of 34 members, of whom 28 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. H. Hall, *Secretary*.

H. M. Boylston, *Chairman*.

REPORT OF COMMITTEE A-5
ON
CORROSION OF IRON AND STEEL

The Report of Committee A-5 consists of the reports of Sub-Committee III on Inspection of the Fort Sheridan, Pittsburgh and Annapolis Tests, Sub-Committee V on Total Immersion Tests and of a Special Sub-Committee on Methods of Sampling and Analysis of Metallic Coated Products.

Sub-Committee III has completed its work at the Pittsburgh location, these tests being abandoned as having served their full usefulness at the close of the inspection of March 9, 1923. Attention is directed to the summary presenting in condensed form the order of resistance to corrosion for the various types of metal exposed at Pittsburgh. It will be observed that the presence of copper in all of the various types of metal has greatly increased their resistance to corrosion under atmospheric exposure. However, in preparing specifications for copper steel or iron, it should be borne in mind clearly that the analyses given for each type are average figures and full allowance must accordingly be made for ranges in all the elements in keeping with good commercial practice. The results at the Fort Sheridan tests continue to show some failure in the light gage low-copper groups of sheets, the same groups having been among the first to fail at Pittsburgh. No failures have occurred at the Annapolis, Md., location. The report as a whole, reviewing the results of these comprehensive tests covering a period of about six years, may be studied with considerable profit to those having unsolved problems in atmospheric corrosion.

Sub-Committee V reports quite a number of failures in the light gage samples exposed at the U. S. Bureau of Standards, Washington, D. C.; a few of the light gage samples have failed also at the Naval Experimental Station location. None of the heavy gage samples have failed at either location. It is also noted that copper added to the metals does not appear to be a factor in rust resistance when the metals are totally and continuously submerged in running water.

In response to a very definite desire for some standard procedure for the sampling and analysis of metallic coatings for iron or steel, the special sub-committee on this subject presents as tentative standards the details for several well-recognized methods now in quite general use, stating in each case the limitations surrounding each method. It is recommended by Committee A-5 that these methods be accepted for publication as tentative. In addition the details for several methods suitable for application in the field are given as information.

This report has been submitted to letter ballot of the committee, which consists of 43 members, of whom 25 have voted affirmatively, none negatively, and 18 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. H. GIBBONEY,
Chairman.

D. M. BUCK,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Determining Weight of Coating on Zinc-Coated Articles; and the proposed Tentative Methods of Determining Weight of Coating on Tin, Terne and Lead-Coated Sheets, referred to in this report, were accepted for publication as tentative and appear on pages 566 to 576.

REPORT OF SUB-COMMITTEE III ON INSPECTION OF THE FORT SHERIDAN, PITTSBURGH, AND ANNAPOLIS TESTS

Sub-Committee III on Inspection has held three meetings during the past year.

FIRST MEETING

The first meeting was held at Fort Sheridan, Ill., on October 16, 1922, with Messrs. Aupperle, Buck, Fleming, Gibboney, Llewelyn, and McDonnell present, Messrs. Cooper, Smith and the representatives of the Quartermaster's Corps of the U. S. War Department, being absent.

The Fort Sheridan sheets were inspected on October 16, 1922, followed by the inspection of the Pittsburgh sheets on October 17, 1922, and the Annapolis sheets on October 18, 1922. Mr. Cooper joined the sub-committee at Pittsburgh, the Bureau of Steam Engineering of the U. S. Navy Department was not represented at Pittsburgh, but joined the sub-committee at Annapolis, and Mr. Gibboney left the sub-committee at Pittsburgh, not making the Annapolis inspection. Members filing data sheets for these inspections are as follows:

Fort Sheridan.—Messrs. Aupperle, Buck, Fleming, Gibboney, Llewelyn, and McDonnell.

Pittsburgh.—No detail information for condition of rust recorded; new failures reported by Messrs. Aupperle, Buck, Cooper, Fleming, Gibboney, and McDonnell.

Annapolis.—No detail information for condition of rust recorded.

The results of the Fort Sheridan inspection in composite form have been filed in the office of the Society. Copies may be obtained upon application to the Secretary-Treasurer.

The following photographs of the Fort Sheridan sheets showing failures taking place at this location since the inspection of April 10, 1922, were made on October 16, 1922, representing an exposure period of sixty-six months.

Fig. 1 represents the general view of the Fort Sheridan sheets as appearing on the racks at this inspection.

Fig. 2 represents the condition of Sheet A 22 (No. 22 Gage Bessemer Steel, Series A), having failed due to small hole in lower end.

Fig. 3 represents the condition of Sheet D 22 (No. 22 Gage Low-Copper Pure Iron, Series A) having failed due to hole in lower end.

Fig. 4 represents the condition of Sheet S 15 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co. This sheet failed due to holes in lower end and completes the failures for this entire group of 14 sheets, 5 sheets having failed after an exposure of 54 months and 8 additional sheets after 60 months.

Figs. 5 and 6 represent the condition of Sheets X 15 and 17 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co. These sheets failed due to holes in the lower end.

The following photographs of the Pittsburgh sheets showing failures taking place at this location since the inspection of April 11, 1922, were made on October 17, 1922, representing an exposure period of 70 months.

Fig. 7 represents the condition of Sheet H 41 (No. 22 Gage Copper-Bearing Open-hearth Steel, Series A), failed due to holes in lower end, and completes the failure of this entire group of 12 sheets, 9 sheets having failed after an exposure of 52 months, 1 sheet after 58 months, and 1 additional sheet after 64 months.

Figs. 8, 9, 10, and 11 represent the condition of Sheets K 34, 42 and 43, 45 and 46, 47 and 48 (No. 22 Gage Copper-Bearing Acid Open-hearth Steel, Series A), failing due to holes in the lower ends.

Figs. 12, 13, 14, and 15 represent the condition of Sheets Z 111 and 112, 209 and 213, 310 and 314 (No. 22 Gage Bessemer Steel, varying Copper Content, Series B), manufactured by the Youngstown Sheet and Tube Co., these sheets having failed due to holes in the lower ends, completing the failures for all light gage sheets of copper-bearing and non-copper-bearing Z groups. The non-copper-bearing groups (0.013 per cent) failed after an exposure of 16 to 22 months, while the 2 copper-bearing groups (0.257 per cent and 0.533 per cent) did not fail until 64 to 70 months' exposure. The group of three sheets arbitrarily classified as non-copper-bearing (0.133 per cent) due to the copper content being below 0.15 per cent, gave results approximating the copper-bearing sheets, 1 sheet failing after 54 months' and 2 sheets after 70 months' exposure.

Fig. 16 represents the condition of Sheet BB 24 (No. 16 Gage Open-hearth Steel, Series A), having failed due to holes and ragged edges at lower end.

Figs. 17, 18, and 19 represent the condition of Sheets CC 16, 31, and 33 (No. 16 Gage Copper-Bearing Pure Iron, Series A), having failed due to holes in the lower ends.

Fig. 20 represents the condition of Sheets DD 47 and 48 (No. 16 Gage Low-Copper Pure Iron, Series A), having failed due to holes and ragged edges at the lower ends.

Figs. 21, 22, 23, and 24 represent the condition of Sheets MM 31 and 32, 37, 39, and 42 (No. 16 Gage Open-hearth Steel, Series B), manufactured by the Alan Wood Iron and Steel Co. These sheets have failed due to small holes and ragged edges at lower ends.

Fig. 25 represents the condition of Sheet OO 32 (No. 16 Gage Low-Copper Open-hearth Steel, Series A), having failed due to small holes and splits in the lower end. This failure completes the group of 12 low-copper open-hearth steel sheets, 1 sheet having failed after an exposure of 46 months, 4 sheets after 52 months, and 6 sheets after 58 months.

Fig. 26 represents the condition of Sheet ZZ 427 (No. 16 Gage Low-Copper Open-hearth Steel, Series B), manufactured by the Youngstown Sheet and Tube Co This sheet failed due to hole in the lower end.

The rate of corrosion for the test sheets at Annapolis continues slow, and no failures have occurred at this location after an exposure of 72 months.

SECOND MEETING

The second meeting was scheduled to be held at Fort Sheridan, Ill., on March 8, 1923, but the inspection at this point was cancelled because of unfavorable weather conditions. Mr. H. E. Smith made an inspection of the Fort Sheridan sheets on March 8, 1923, and reports no new failures at this location since the inspection of October 16, 1922.

The Pittsburgh sheets were inspected by Messrs. Buck and Smith on March 9, 1923, and by Mr. Aupperle on March 16, 1923, and the following photographs of sheets showing failures at this location were made on March 9, 1923.

Fig. 28 represents the general view for the Pittsburgh sheets as appearing on the racks at this inspection. This will be the last photograph of these sheets, the test being abandoned following this inspection and the sheets scrapped.

Fig. 27 represents the condition of Sheet DD 56 (No. 16 Gage Low-Copper Pure Iron, Series A). This sheet failed due to hole in lower end and completes the failures of this entire group of 18 low-copper pure iron sheets, failures being recorded at the end of 52, 58 and 64 months, respectively.

Sheet Z 712 (No. 22 Gage Copper-Bearing Open-hearth Steel, varying copper content, Series B) manufactured by the Youngstown Sheet and Tube Co., failed due to holes in the lower end. No photograph was taken of this sheet due to inability because of location to place the photographic tower in position for the exposure. The failure of this sheet completes the group of 9 copper-bearing open-hearth steel sheets, failures being reported at the end of 52, 58 and 64 months.

Annapolis sheets were not included in the inspection program at this time due to the report from Mr. McAdam, a member of the sub-committee stationed at the U. S. Naval Experiment Station, to the effect that no failures had occurred at this location up to March 5, 1923, representing an exposure period of 77 months.

The sub-committee at its inspections of October, 1922, and March, 1923, observed that the conditions of the surfaces of the sheets at the various locations as regards texture, color and adherence of rust showed substantially the same general chraacteristics as recorded at the last preceding inspections and for this reason detail data in the form of condensed statements of numeral ratings are not made a part of this report.

Table I, Plate I, is presented as a continuation of the same general plan of grouping the sheets at Fort Sheridan as shown in Table VII of the 1922 report, recording such additional failures as have occurred during the past year. It will be observed that the entire group of 14 sheets, low-copper pure iron, are now listed as failures along with the groups of low-copper open-hearth steel and bessemer steel sheets, these same groups of sheets being among the first to fail at the Pittsburgh location.

At the time of the March 8, 1923, inspection, representing an exposure period of 71 months, 42 out of a total of 83 of the No. 22 gage non-copper-bearing metal sheets have been recorded as failures, whereas during the same period of exposure no singlefailure has been recorded for the copper-bearing metal sheets, indicating conclusively that copper-bearing metal in the Fort Sheridan location shows marked superiority in rust resisting properties as compared with non-copper-bearing metal of the same general composition.

Table II, Plate II, is presented as a continuation of the grouping of the Pittsburgh sheets as shown in Table VIII of the 1922 report, recording such additional failures as have occurred during the past year. At the end of 75 months' exposure there remains but one complete group of 18 light gage sheets without a failure, this group being classified as copper-bearing bessemer steel. This particular group of sheets has shown marked rust resisting properties, the rust being very fine in texture, dark brown in color and adhering very tightly to the surface of the sheet. Of the heavy No. 16 gage sheets, 102 of the total of 126 non-copper-bearing metal sheets have failed, whereas no failures have been observed for the copper-bearing metal sheets.

TABLE I.—FAILURES AT FORT SHERIDAN TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, 1922 AND MARCH, 1923.

Group.	Designation.	Series.	Description.	Average Analysis.						Number of Sheets in Test.
				Carbon.	Manganese.	Phosphorus.	Sulfur.	Silicon.	Copper.	
										No. 16 GAGE SHEE
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319	12
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.237	17
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247	19
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234	19
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236	12
TT	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.080	0.313	0.009	0.020	0.006	0.223	14
UU	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.018	0.066	0.008	0.028	0.005	0.239	13
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.046	0.007	0.019	0.004	0.299	19
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.08	0.40	0.091	0.035	0.006	0.154	1
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.08	0.34	0.094	0.037	.....	0.279	2
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.36	0.082	0.033	.....	0.528	2
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.37	0.050	0.052	.....	0.172	2
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.09	0.34	0.038	0.077	0.003	0.641	2
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.39	0.049	0.044	.....	0.318	2
	Total	.....	.....	.....	.....	.....	.....	.....	.....	136
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012	17
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.129	17
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067	12
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028	19
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029	12
MM	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" " "	0.017	0.414	0.010	0.029	0.007	0.057	14
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025	12
XX	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028	14
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023	3
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.08	0.45	0.102	0.037	0.008	0.014	2
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.022	0.39	0.040	0.028	.....	0.030	2
	Total	.....	.....	.....	.....	.....	.....	.....	.....	124
										No. 22 GAGE SHEET
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.156	2
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.195	10
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283	12
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244	11
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252	19
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237	16
M	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" "	0.093	0.419	0.013	0.041	0.011	0.185	14
T	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.083	0.313	0.009	0.020	0.005	0.227	14
U	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.017	0.074	0.008	0.037	0.005	0.260	14
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.051	0.007	0.021	0.005	0.304	14
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.37	0.094	0.038	0.007	0.263	2
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.05	0.37	0.114	0.048	.....	0.533	2
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.35	0.049	0.059	.....	0.212	2
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.39	0.047	0.047	.....	0.286	2
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.41	0.042	0.042	.....	0.532	2
	Total	.....	.....	.....	.....	.....	.....	.....	.....	136
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014	15
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.103	11
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.144	2
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024	6
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020	12
S	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022	14
X	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027	14
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020	3
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.07	0.44	0.107	0.046	0.003	0.011	2
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.06	0.38	0.077	0.035	0.009	0.130	2
Z	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.06	0.32	0.065	0.044	0.002	0.018	2
	Total	.....	.....	.....	.....	.....	.....	.....	.....	83

[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.

[a] No failures were recorded at inspections made prior to March 31, 1919; the detail records are accordingly not given here.

1923. SHEETS EXPOSED APRIL 9, 1917. COMPARING COPPER-BEARING WITH NON-COPPER-BEARING MATERIALS.[1]

umber Sheets n Test.	Date of Inspection.									Number of Sheets Failed in Test.
	March 31, 1919.[a] 24 Months.	Dec. 6, 1919. 32 Months.	May 10, 1920. 37 Months.	Oct. 11, 1920. 42 Months.	April 4, 1921. 48 Months.	Oct. 17, 1921. 54 Months.	April 10, 1922. 60 Months.	Oct. 16, 1922. 66 Months.	Mar. 8, 1923. 71 Months.	
E SHEETS.										
12	None	None	None	None	None	None	None	None	None	None
17	None	None	None	None	None	None	None	None	None	None
19	None	None	None	None	None	None	None	None	None	None
19	None	None	None	None	None	None	None	None	None	None
12	None	None	None	None	None	None	None	None	None	None
14	None	None	None	None	None	None	None	None	None	None
13	None	None	None	None	None	None	None	None	None	None
19	None	None	None	None	None	None	None	None	None	None
1	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
136	None	None	None	None	None	None	None	None	None	None
17	None	None	None	None	None	13 (1)	None	None	None	1
17	None	None	None	None	None	None	None	None	None	None
12	None	None	None	None	None	None	None	None	None	None
19	None	None	None	None	None	None	None	None	None	None
12	None	None	None	None	None	None	None	None	None	None
14	None	None	None	None	None	None	None	None	None	None
12	None	None	None	None	None	None	None	None	None	None
14	None	None	None	None	None	None	None	None	None	None
3	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
124	None	None	None	None	None	1	None	None	None	1
SHEETS.										
2	None	None	None	None	None	None	None	None	None	None
10	None	None	None	None	None	None	None	None	None	None
12	None	None	None	None	None	None	None	None	None	None
11	None	None	None	None	None	None	None	None	None	None
19	None	None	None	None	None	None	None	None	None	None
16	None	None	None	None	None	None	None	None	None	None
14	None	None	None	None	None	None	None	None	None	None
14	None	None	None	None	None	None	None	None	None	None
14	None	None	None	None	None	None	None	None	None	None
14	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
36	None	None	None	None	None	None	None	None	None	None
15	None	None	16, 17, 18 (3)	None	19, 29, 30 (3)	None	None	22 (1)	None	7
11	None	None	None	None	None	None	None	None	None	None
2	None	None	None	None	None	None	None	None	None	None
6	None	None	None	None	None	None	None	22 (1)	None	1
12	None	14, 15, 21 (3)	13, 16, 19, 23, 24 (5)	17, 18, 20, 22 (4)	....	....	....	....	....	12 (All)
14	None	None	None	None	None	16, 22, 25, 26, 28 (5)	17, 18, 19, 20, 21 23, 24, 27 (8)	15 (1)	....	14 (All)
14	None	None	None	None	25 (1)	None	None	15, 17 (2)	None	3
3	None	None	None	4 (1)	None	None	None	None	None	1
2	None	None	None	None	4, 5 (2)	....	....	....	....	2 (All)
2	None	None	None	None	None	None	None	None	None	None
2	None	None	421 (1)	None	None	420 (1)	....	....	....	2 (All)
83	None	3	9	5	6	6	8	5	0	42

TABLE II.—FAILURES AT PITTSBURGH TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, 1922 AND MARCH, 1923.

Group.	Designation.	Series.	Description.	Average Analysis.						Number of Sheets in Test.		
				Carbon.	Manganese.	Phosphorus.	Sulfur.	Silicon.	Copper.		Oct. 9, 1917. 10 Months.	A
											No. 16 Gage S	
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319	12	None	
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.237	15	None	
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247	18	None	
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234	19	None	
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236	12	None	
TT	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.080	0.313	0.009	0.020	0.006	0.223	14	None	
UU	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.018	0.066	0.008	0.028	0.005	0.239	14	None	
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.046	0.007	0.019	0.004	0.299	13	None	
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.08	0.40	0.092	0.037	0.004	0.153	1	None	
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.09	0.31	0.088	0.047	.....	0.271	3	None	
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.36	0.085	0.033	.....	0.549	3	None	
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.37	0.054	0.064	.....	0.223	3	None	
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.09	0.33	0.032	0.056	0.003	0.575	3	None	
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.40	0.056	0.048	.....	0.364	2	None	
	Total			.....	.....	.....	.....	.....	.....	132	None	
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012	17	None	
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.113	17	None	
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067	12	None	
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028	18	None	
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029	12	None	
MM	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" " "	0.017	0.414	0.010	0.029	0.007	0.057	14	None	
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025	14	None	
XX	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028	14	None	
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023	3	None	
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.07	0.40	0.097	0.037	0.008	0.013	3	None	
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.032	0.40	0.044	0.028	.....	0.028	2	None	
	Total			.....	.....	.....	.....	.....	.....	126	None	
											No. 22 Gage Sh	
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.179	9	None	
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.190	9	None	
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283	12	None	
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244	12	None	
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252	18	None	
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237	16	None	
M	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	" "	0.093	0.419	0.013	0.041	0.011	0.185	14	None	
T	Copper-Bearing Steel, Newport Rolling Mill Co.	B	" "	0.083	0.313	0.009	0.020	0.005	0.227	14	None	
U	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	" "	0.017	0.074	0.008	0.037	0.005	0.260	14	None	
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	" "	0.018	0.051	0.007	0.021	0.005	0.304	14	None	
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.039	0.37	0.084	0.038	0.007	0.257	3	None	
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	" "	0.043	0.37	0.100	0.045	.....	0.533	2	None	
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.35	0.049	0.059	.....	0.212	3	None	
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.39	0.059	0.058	.....	0.268	3	None	
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.41	0.050	0.050	.....	0.621	3	None	
	Total			.....	.....	.....	.....	.....	.....	146	None	
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014	17	None	31, 36, 42,
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.082	4	None	
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.139	2	None	
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024	9	None	
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020	12	None	25, 30, 3
S	Low-Copper Pure Iron, American Rolling Mill Co.	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022	14	None	
X	Low-Copper Pure Iron, Inland Steel Co.	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027	14	None	
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020	3	None	
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.055	0.37	0.119	0.048	0.003	0.013	3	None	
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	" " "	0.07	0.40	0.088	0.048	0.009	0.133	3	None	
Z	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	" " "	0.10	0.32	0.069	0.044	0.002	0.018	3	None	
	Total			.....	.....	.....	.....	.....	.....	84	None	

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent as copper-bearing.

[2] These "Y" Sheets were reported as failures at the Nov. 5, 1919, inspection, but are placed in this column because they were exposed about six months later than all other sheets.

PLATE II.
PROC. AM. SOC. TESTING MATS.
VOL. 23, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

1923. Sheets Exposed December 12, 1916. Comparing Copper-Bearing with Non-Copper-Bearing Materials.[1]

	Date of Inspection.											Number of sheets Failed in Test.
917. hs.	April 9, 1918. 16 Months.	Oct. 7, 1918. 22 Months.	April 1, 1919. 28 Months.	Nov. 5, 1919. 35 Months.	May 11, 1920. 41 Months.	Oct. 12, 1920. 46 Months.	April 5, 1921. 52 Months.	Oct. 18, 1921. 58 Months.	April 11, 1922. 64 Months.	Oct. 17, 1922. 70 Months.	Mar. 9, 1923. 75 Months.	
GAGE SHEETS.												
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	25, 26,27, 28, 29 30, 50, 51, 52, 53 54, 55, 56 (**13**)	21, 22, 23, 24 (**4**)	....	....	....	....	....	....	....	17 (All)
	None	None	None	None	None	None	None	23 (**1**)	20, 21 (**2**)	24 (**1**)	None	4
	None	None	None	None	None	None	None	18 (**1**)	15, 17 (**2**)	16, 31, 33 (**3**)	None	6
	None	None	None	None	None	None	25, 26 (**2**)	27, 28, 29, 30, 31 54, 55, 57, 58 (**9**)	8, 9, 49 (**3**)	47, 48 (**2**)	56 (**1**)	17
	None	None	None	None	None	27 (**1**)	25, 26, 28, 33 (**4**)	29, 30, 31, 34, 35 36 (**6**)	None	32 (**1**)	....	12 (All)
	None	None	None	None	None	None	None	29, 30, 35, 38, 40 (**5**)	41 (**1**)	31, 32, 37, 39, 42 (**5**)	None	11
	None	None	None	None	29, 30, 31, 32, 33 35, 39, 40 (**8**)	34, 36, 37, 38, 41 42 (**6**)	....	....	....	....	....	14 (All)
	None	None	None	None	29, 30, 31, 32 41 (**5**)	36 (**1**)	33, 34, 35, 38 39, 40 (**6**)	7, 42 (**2**)	....	....	....	14 (All)
	None	None	None	None	None	None	7, 9 (**2**)	8 (**1**)	....	....	....	3 (All)
	None	None	None	8, 10, 14 (**3**)	....	....	....	....	....	....	....	3 (All)
	None	None	None	None	None	None	None	None	None	427 (1)	None	1
	None	None	13	7	13	8	14	25	8	13	1	102
AGE SHEETS.												
	None.	None	None	17 (**1**)	18 (**1**)	21, 23 (**2**)	22, 34, 39 (**3**)	19, 20 (**2**)	....	....	....	9 (All)
	None	None	None	11, 13, 14, 22 (**4**)	32, 34, 35 (**3**)	33 (**1**)	12 (**1**)	....	....	....	....	9 (All)
	None	32, 36 (**2**)	29, 30, 31, 35 (**4**)	25, 27, 33, 34 (**4**)	26, 28 (**2**)	....	....	....	....	....	....	12 (All)
	None	None	None	None	None	None	38, 40, 42, 45, 49 50, 53, 54, 55 (**9**)	47 (**1**)	43 (**1**)	41 (**1**)	....	12 (All)
	None	None	None	None	None	None	None	None	None	None	None	None
	None	None	None	None	None	None	None	36, 41 (**2**)	37, 39 (**2**)	34, 42, 43, 45, 46 47, 48 (**7**)	None	11
	None	None	None	None	32, 36, 42 (**3**)	39, 41 (**2**)	29, 30, 33, 34, 35 37, 38, 40 (**8**)	31 (**1**)	....	....	....	14 (All)
	None	None	None	37, 39 (**2**)	32, 33, 35 36, 38 (**5**)	29, 30, 31, 34, 40 41, 42 (**7**)	....	....	....	....	....	14 (All)
	None	None	None	41 (**1**)	29, 30, 40 (**3**)	31, 33, 34, 35, 38 42 (**6**)	32, 36, 37 39 (**4**)	....	....	....	....	14 (All)
	None	None	None	29, 39 (**2**)	36, 37, 42 (**3**)	30, 33, 34, 35, 38 40, 41 (**7**)	31, 32 (**2**)	....	....	....	....	14 (All)
	None	None	None	None	None	None	None	None	214 (**1**)	209, 213 (**2**)	....	3 (All)
	None	None	None	None	None	None	None	None	None	310, 314 (**2**)	....	2 (All)
	None	None	None	None	None	None	None	509, 513, 516 (**3**)	....	....	....	3 (All)
	None	None	None	None	None	None	None	607, 608, 609 (**3**)	....	....	....	3 (All)
	None	None	None	None	None	None	715 (**1**)	None	714 (**1**)	None	712 (**1**)	3 (All)
	None	2	4	14	20	25	28	12	5	12	1	123
	31, 32, 33, 34, 35 36, 37. 38, 40, 41 42, 43, 44, 45, 46 47 (**16**)	39 (**1**)	....	....	....	....	....	....	....	....	....	17 (All)
	None	37 (**1**)	38 (**1**)	35 (**1**)	36 (**1**)	....	....	....	....	....	....	4 (All)
	None	None	None	20 (**1**)	21 (**1**)	....	....	....	....	....	....	2 (All)
	None	30, 36, 38 (**3**)	31, 33, 34, 35 39, 40 (**6**)	....	....	....	....	....	....	....	....	9 (All)
	25, 26, 27, 28, 29 30, 31, 32, 33, 34 35, 36 (**12**)	....	....	....	....	....	....	....	....	....	....	12 (All)
	35 (**1**)	29, 30, 31, 32, 33 34, 36, 37, 38, 39 40, 41, 42 (**13**)	....	....	....	....	....	....	....	....	....	14 (All)
	None	29, 30, 31, 32, 33 34, 35, 36, 37,38 39,40,41,42(**14**)	....	....	....	....	....	....	....	....	....	14 (All)
	None	None	7, 8, 9 (**3**)[2]	....	....	....	....	....	....	....	....	3 (All)
	11 (**1**)	6, 7 (**2**)	....	....	....	....	....	....	....	....	....	3 (All)
	None	None	None	None	None	None	113 (**1**)	None	None	111. 112 (**2**)	....	3 (All)
	None	122, 423, 424 (**3**)	....	....	....	....	....	....	....	....	....	3 (All)
	30	37	10	2	2	None	1	None	None	2	....	84 (All)

The following summary is presented as indicating the order of resistance of uncoated sheets to corrosion under atmospheric exposure as recorded for the various types of metals, together with average compositions, for the No. 22 gage sheets at the Pittsburgh location, the most resistant being given first.

Rating	Type Designation	Average Analysis, per cent					
		C.	Mn.	P.	S.	Si.	Cu.
First	Copper-Bearing Bessemer Steel	0.041	0.365	0.097	0.068	0.008	0.252
Second	Copper-Bearing Acid Open-hearth Steel	0.107	0.447	0.091	0.046	0.004	0.237
Third	Copper-Bearing Basic Open-hearth Steel	0.069	0.387	0.016	0.027	0.004	0.244
Fourth	Copper-Bearing Pure Iron[1]	0.016	0.051	0.007	0.031	0.004	0.251
Fifth	Copper-Bearing Wrought Iron	0.033	0.034	0.114	0.021	0.134	0.283
Sixth	Low-Copper Wrought Iron	0.03	0.055	0.139	0.021	0.218	0.020
Seventh	Low-Copper Pure Iron[2]	0.02	0.035	0.006	0.025	0.003	0.024
Eighth	Low-Copper Basic Open-hearth Steel	0.10	0.32	0.069	0.044	0.002	0.018
Ninth	Low-Copper Bessemer Steel	0.038	0.386	0.089	0.040	0.007	0.014

[1] Average of groups C, U and V.
[2] Average of groups D, S and X.

In the No. 16 gage sheets the following order of resistance was recorded, the most resistant being given first. None of the copper-bearing materials has failed.

Rating	Type Designation	Average Analysis, per cent					
		C.	Mn.	P.	S.	Si.	Cu.
First	All Copper-Bearing Materials	.....	.....	.....	.....	.....	.....
Second	Low-Copper Basic Open-hearth Steel	0.108	0.371	0.009	0.029	0.007	0.029
Third	Low-Copper Pure Iron	0.021	0.062	0.008	0.030	0.005	0.028
Fourth	Low-Copper Bessemer Steel	0.043	0.419	0.083	0.042	0.004	0.012

Within the past year, the U. S. War Department has disposed of the Arsenal Grounds wherein the Pittsburgh test racks were located, and since the grounds had to be relinquished the sub-committee by recorded vote registered the unanimous opinion that these tests had served their full usefulness and that the test location and remaining sheets should be abandoned.

Table III is presented as showing in condensed form the composition of groups of sheets that have completely failed at the Pittsburgh location at the close of the test, March 9, 1923.

Table IV is presented as showing in condensed form the composition of groups of sheets that have completely failed at the Fort Sheridan location at the time of the inspection of March 8, 1923. No further detailed record for these sheets will appear in future reports.

At the close of approximately six years' observations of these tests, the sub-committee would again direct attention to the fact that the failures recorded at the Pittsburgh and Fort Sheridan locations point definitely to the conclusion that copper-bearing metal

TABLE III.—AVERAGE COMPOSITIONS OF GROUPS OF SHEETS OF PITTSBURGH TESTS THAT HAVE COMPLETELY FAILED

Sheets Exposed December 12, 1916

Group	Type Designation	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper per cent
A 31–47	No. 22 Gage Bessemer Steel, Series A	0.038	0.386	0.089	0.040	0.007	0.014
B 35–38	No. 22 Gage Open-hearth Steel, Series A	0.09	0.38	0.017	0.062	0.036	0.082
B 17–23 B 34–39	No. 22 Gage Open-hearth Steel, Series A	0.06	0.27	0.014	0.053	0.006	0.179
C 11–14 C 32–35	No. 22 Gage Copper-Bearing Pure Iron, Series A.	0.015	0.028	0.006	0.036	0.003	0.190
C 20–22	No. 22 Gage Copper-Bearing Pure Iron, Series A.	0.01	0.028	0.002	0.027	0.002	0.139
D 30–40	No. 22 Gage Low-Copper Pure Iron, Series A	0.020	0.026	0.004	0.022	0.002	0.024
E 25–36	No. 22 Gage Puddled Iron, Series A	0.033	0.034	0.114	0.021	0.134	0.283
H 38, 40–43 H 45, 47, 49, 50 H 53, 54, 55	No. 22 Gage Copper-Bearing Basic Open-hearth Steel, Series A	0.069	0.39	0.016	0.027	0.004	0.244
M 29–42	No. 22 Gage Open-hearth Steel, Series B, Alan Wood Iron and Steel Co	0.093	0.419	0.013	0.041	0.011	0.185
O 25–36	No. 22 Gage Open-hearth Steel, Series A	0.121	0.536	0.008	0.030	0.249	0.020
S 29–42	No. 22 Gage Low-Copper Pure Iron, Series B, American Rolling Mill Co	0.020	0.023	0.006	0.022	0.004	0.022
T 29–42	No. 22 Gage Copper-Bearing Steel, Series B, Newport Rolling Mill Co	0.083	0.313	0.009	0.020	0.005	0.227
U 29–42	No. 22 Gage Copper-Bearing Pure Iron, Series B, Allegheny Steel Co	0.017	0.074	0.008	0.037	0.005	0.260
V 29–42	No. 22 Gage Copper-Bearing Pure Iron, Series B, Whitaker-Glessner Co	0.018	0.051	0.007	0.021	0.005	0.304
X 29–42	No. 22 Gage Low-Copper Pure Iron, Series B, Inland Steel Co	0.021	0.055	0.007	0.031	0.004	0.027
Y 7–9[a]	No. 22 Gage Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co	0.03	0.055	0.139	0.021	0.218	0.020
Z 6, 7, 11	No. 22 Gage Bessemer Steel, Series B, Youngstown Sheet and Tube Co	0.055	0.37	0.119	0.048	0.003	0.013
Z 422, 423, 424	No. 22 Gage Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.10	0.32	0.069	0.044	0.002	0.018
Z 509, 513, 516	No. 22 Gage Copper-Bearing Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.06	0.35	0.049	0.059	.....	0.212
Z 607, 608, 609	No. 22 Gage Copper-Bearing Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.07	0.39	0.059	0.058	.....	0.268
Z 712, 714, 715	No. 22 Gage Copper-Bearing Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.07	0.41	0.050	0.050	.....	0.621
AA 21–30 AA 50–56[b]	No. 16 Gage Bessemer Steel, Series A	0.043	0.419	0.083	0.042	0.004	0.012
DD 25–28 DD 8–10 DD 29–31 DD 47–49 DD 54–58	No. 16 Gage Low-Copper Pure Iron, Series A	0.019	0.028	0.004	0.027	0.004	0.028
OO 25–36	No. 16 Gage Low-Copper Open-hearth Steel, Series A	0.108	0.371	0.009	0.029	0.007	0.029
SS 29–42	No. 16 Gage Low-Copper Pure Iron, Series B, American Rolling Mill Co	0.017	0.021	0.006	0.021	0.006	0.025
XX 29–42	No. 16 Gage Low-Copper Pure Iron, Series B, Inland Steel Co	0.021	0.062	0.008	0.030	0.005	0.028
ZZ 8, 10, 14	No. 16 Gage Bessemer Steel, Series B, Youngstown Sheet and Tube Co	0.07	0.40	0.097	0.037	0.008	0.013
YY 7, 8, 9	No. 16 Gage Low-Copper Wrought Iron, Series B, Youngstown Sheet and Tube Co	0.03	0.051	0.123	0.019	0.203	0.023

[a] Y Sheets exposed June 2, 1917.
[b] AA Sheets 50–56 sand blasted.

shows marked superiority in rust resisting properties as compared to non-copper-bearing metal of substantially the same general composition under atmospheric exposure.

THIRD MEETING

The third meeting of the sub-committee was held in Philadelphia, Pa., on April 25, 1923, at which time the report of the sub-committee was considered and unanimously approved.

TABLE IV.—AVERAGE COMPOSITIONS OF GROUPS OF SHEETS OF FORT SHERIDAN TESTS THAT HAVE COMPLETELY FAILED

Sheets Exposed April 9, 1917

Group	Type Designation	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent	Copper, per cent
O 13–24	No. 22 Gage Low-Copper Open-hearth Steel, Series A	0.121	0.536	0.008	0.030	0.249	0.020
S 15–28	No. 22 Gage Low-Copper Pure Iron, Series B, American Rolling Mill Co	0.02	0.023	0.006	0.022	0.004	0.022
Z 4, 5	No. 22 Gage Bessemer Steel, Series B, Youngstown Sheet and Tube Co	0.07	0.44	0.107	0.046	0.003	0.011
Z 420, 421	No. 22 Gage Open-hearth Steel, Series B, Youngstown Sheet and Tube Co	0.06	0.32	0.065	0.044	0.002	0.018

Respectfully submitted on behalf of the sub-committee,

J. H. GIBBONEY,
Chairman.

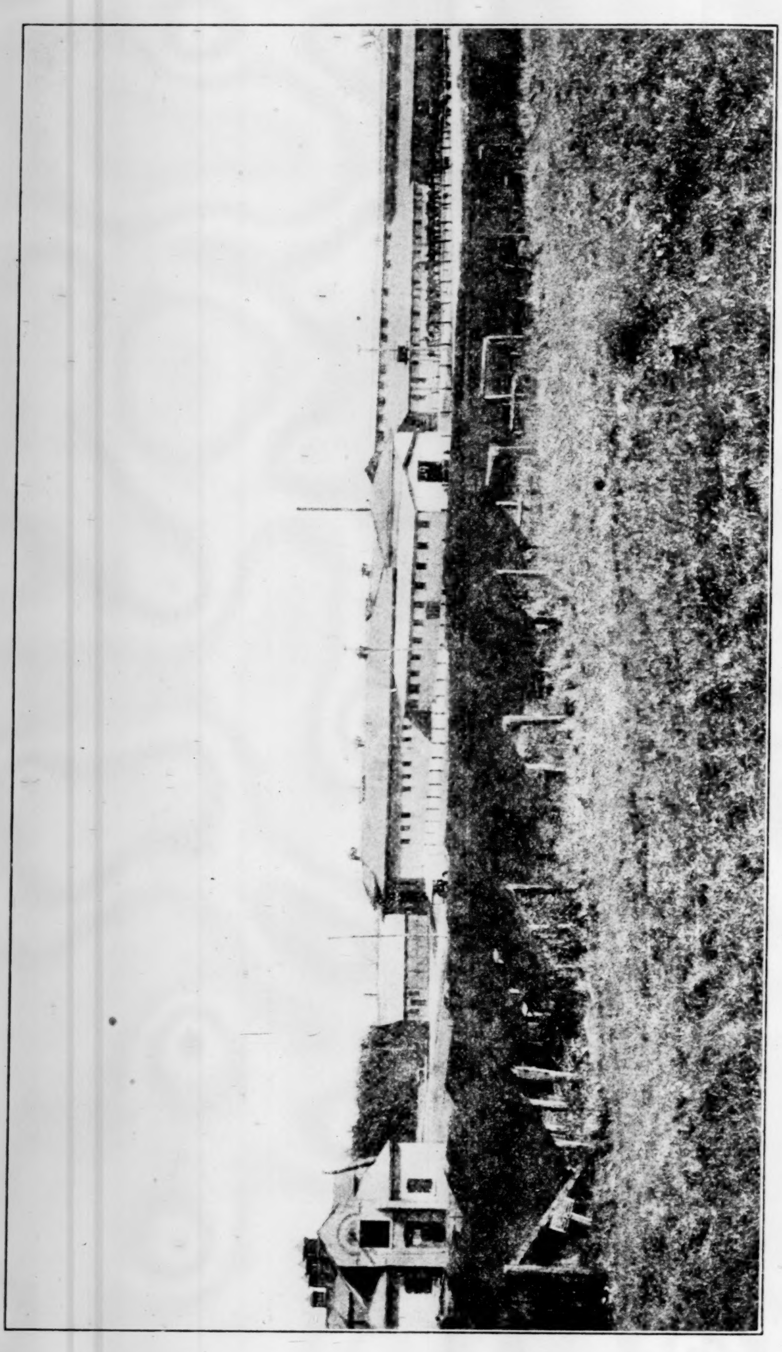

FIG. 1.—GENERAL VIEW OF FORT SHERIDAN TEST RACK, OCTOBER 16, 1922

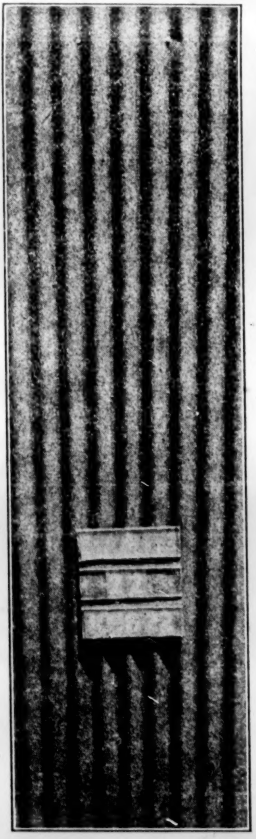

FIG. 2.—FORT SHERIDAN TESTS
No. 22 GAGE BESSEMER STEEL—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
A 22....	0.05	0.40	0.093	0.036	Trace	0.020	....

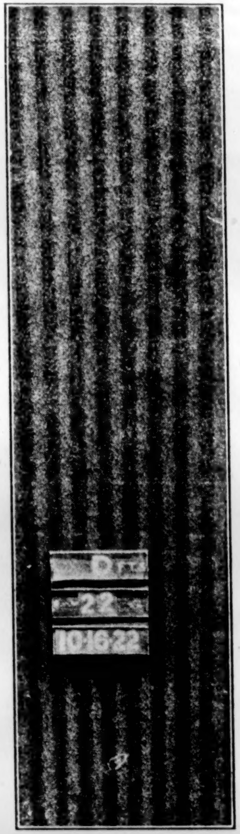

FIG. 3.—FORT SHERIDAN TESTS
No. 22 GAGE LOW-COPPER PURE IRON—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.,
D 22....	0.01	0.020	0.003	0.023	0.0020	0.025	....

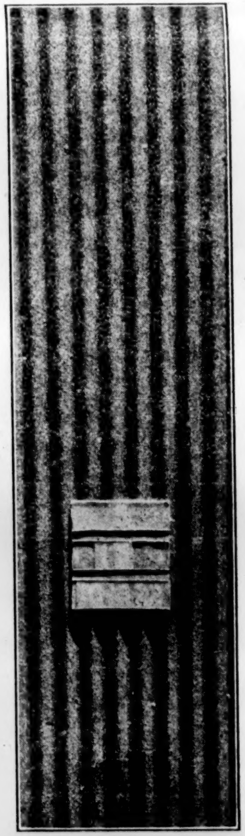

FIG. 4.—FORT SHERIDAN TESTS
No. 22 GAGE LOW-COPPER PURE IRON—SERIES B
AMERICAN ROLLING MILL CO.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
S 15....	0.03	0.03	0.003	0.015	0.006	0.018	0.031

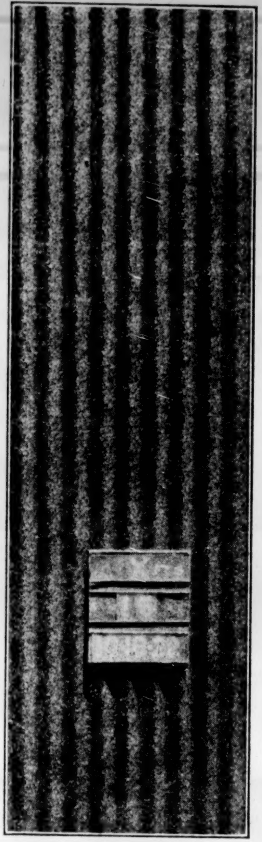

FIG. 5.—FORT SHERIDAN TESTS

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B

INLAND STEEL CO.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
X 15...	0.014	0.042	0.008	0.036	0.002	0.028	0.043

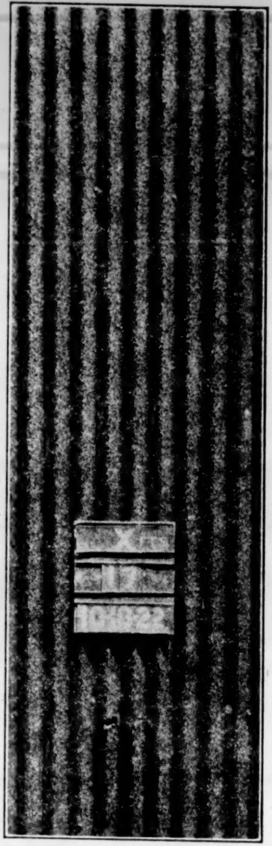

FIG. 6.—FORT SHERIDAN TESTS

NO. 22 GAGE LOW-COPPER PURE IRON—SERIES B

INLAND STEEL CO.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
X 17...	0.018	0.04	0.006	0.026	....	0.024	....

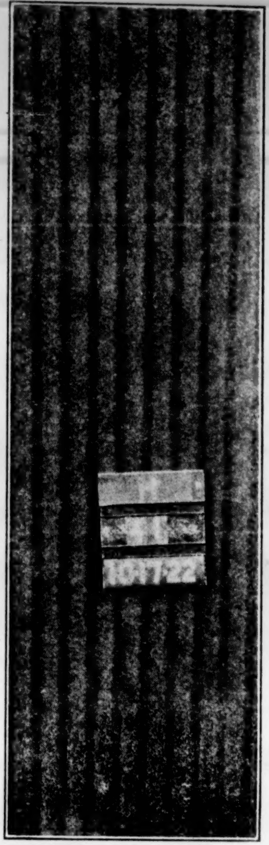

FIG. 7.—PITTSBURGH TESTS

NO. 22 GAGE COPPER-BEARING BASIC OPEN-HEARTH STEEL—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu	Ni.
H 41....	0.08	0.44	0.058	0.029	....	0.26	0.01

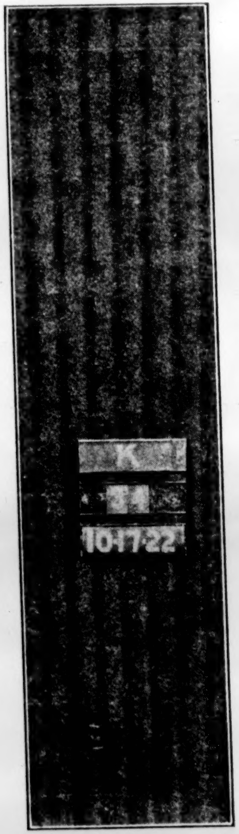

FIG. 8.—PITTSBURGH TESTS
No 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—
SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 34...	0.12	0.47	0.101	0.047	....	0.25	....

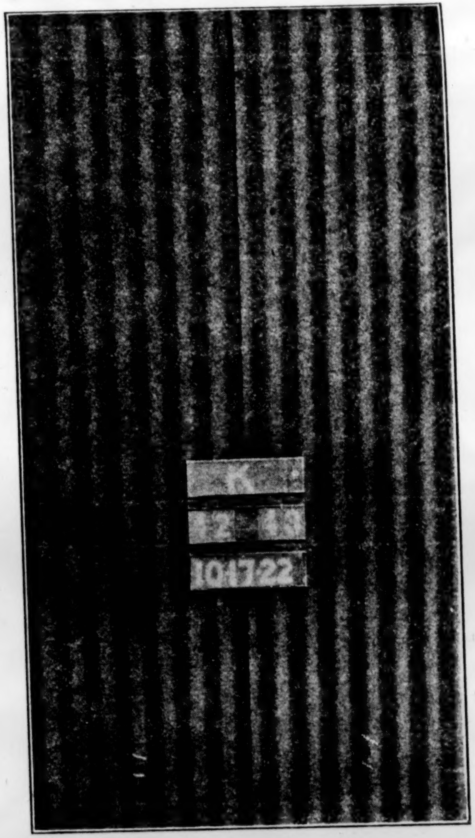

FIG. 9.—PITTSBURGH TESTS
No. 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—
SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 42....	0.10	0.46	0.092	0.047	....	0.24	....
K 43....	0.08	0.47	0.083	0.041	0.011	0.24	0.008

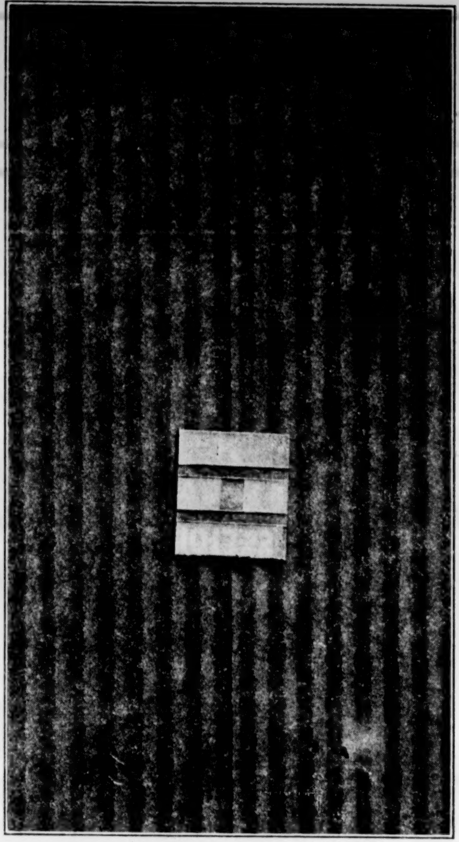

FIG. 10.—PITTSBURGH TESTS
NO. 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 45....	0.11	0.46	0.110	0.053	....	0.24	....
K 46....	0.10	0.45	0.083	0.046	....	0.23	....

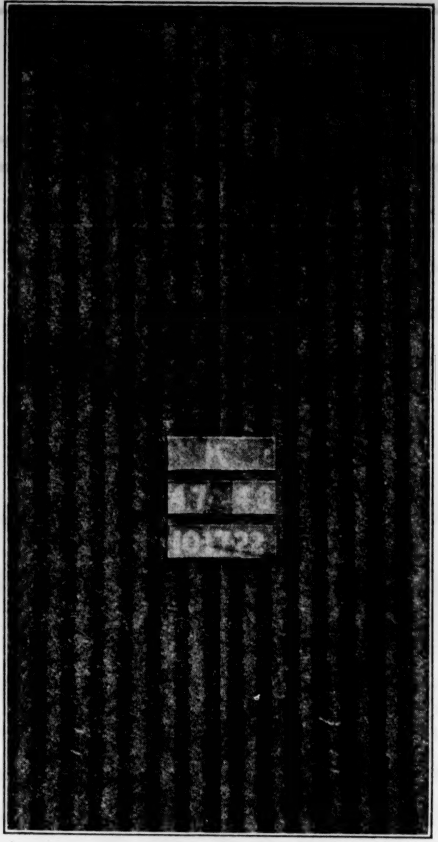

FIG. 11.—PITTSBURGH TESTS
NO. 22 GAGE COPPER-BEARING ACID OPEN-HEARTH STEEL—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
K 47....	0.09	0.46	0.082	0.047	....	0.23	....
K 48....	0.11	0.46	0.077	0.043	0.008	0.22	....

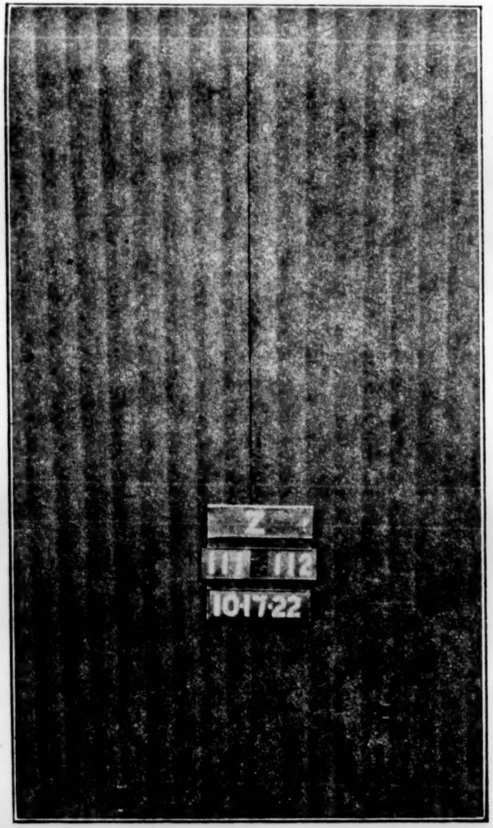

Fig. 12.—Pittsburgh Tests
No. 22 Gage Bessemer Steel—Series B
Youngstown Sheet and Tube Co.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 111...	0.07	0.42	0.095	0.050	0.009	0.138	None
Z 112...	0.07	0.42	0.081	0.048	0.009	0.134	None

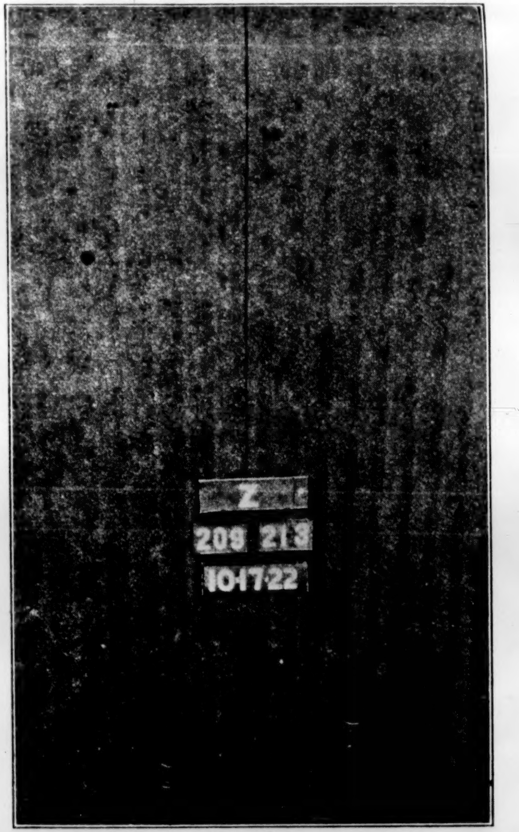

Fig. 13.—Pittsburgh Tests
No. 22 Gage Bessemer Steel—Series B
Youngstown Sheet and Tube Co.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 209..	0.06	0.39	0.093	0.035	0.007	0.261	None
Z 213..	0.019	0.362	0.078	0.038	0.007	0.250	None

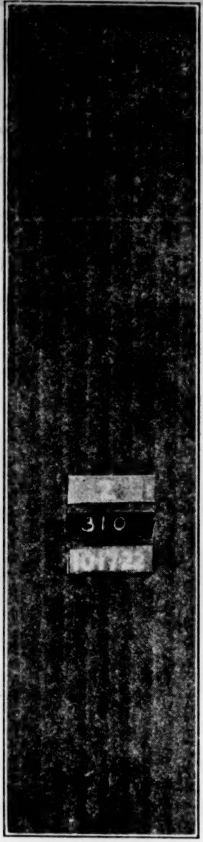

FIG. 14.—PITTSBURGH TESTS
NO. 22 GAGE BESSEMER STEEL (VARYING COPPER CONTENT)—SERIES B
YOUNGSTOWN SHEET AND TUBE CO.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 310.	0.03	0.36	0.075	0.042	0.009	0.488	None

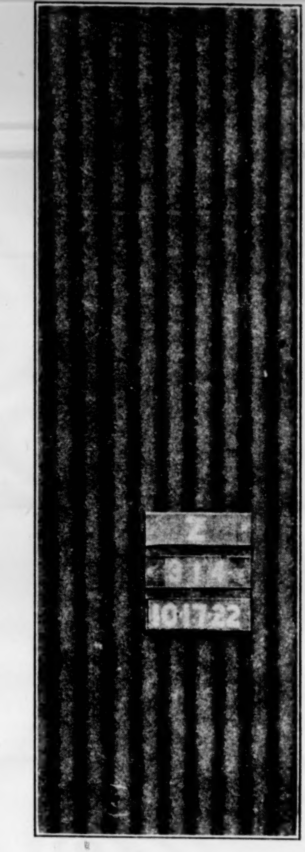

FIG. 15.—PITTSBURGH TESTS
NO. 22 GAGE BESSEMER STEEL—SERIES B
YOUNGSTOWN SHEET AND TUBE CO.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
Z 314.	0.028	0.36	0.077	0.039	....	0.536	....

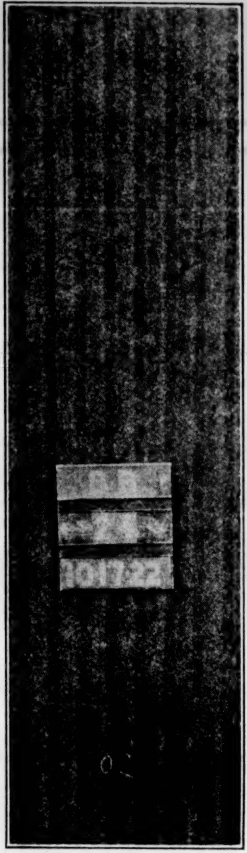

FIG. 16.—PITTSBURGH TESTS
NO. 16 GAGE OPEN-HEARTH STEEL—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
BB 24.	0.06	0.049	0.027	0.023	0.009	0.042	....

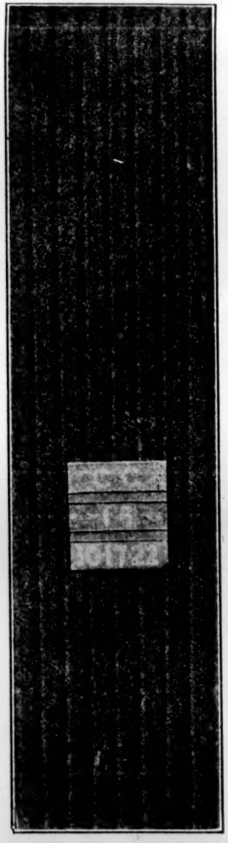

FIG. 17.—PITTSBURGH TESTS
No. 16 GAGE COPPER-BEARING PURE IRON—
SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
CC 16 ..	0.01	0.024	0.002	0.032	0.002	0.060	....

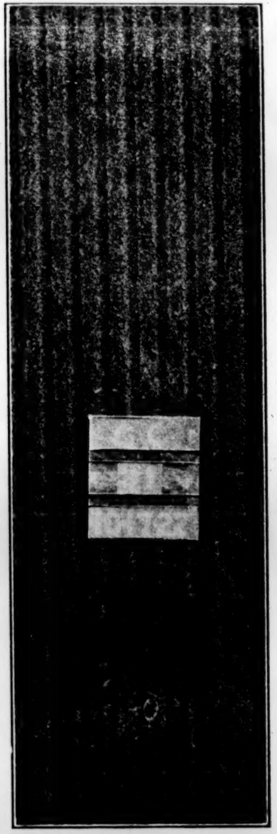

FIG. 18.—PITTSBURGH TESTS
No. 16 GAGE COPPER-BEARING PURE IRON—
SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
CC 31 ..	0.03	0.03	0.005	0.028	....	0.042	....

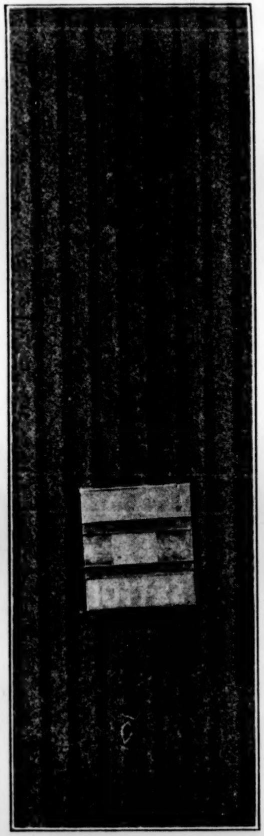

FIG. 19.—PITTSBURGH TESTS
No. 16 GAGE COPPER-BEARING PURE IRON—
SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
CC 33.	0.01	0.03	0.003	0.029	....	0.044	0.008

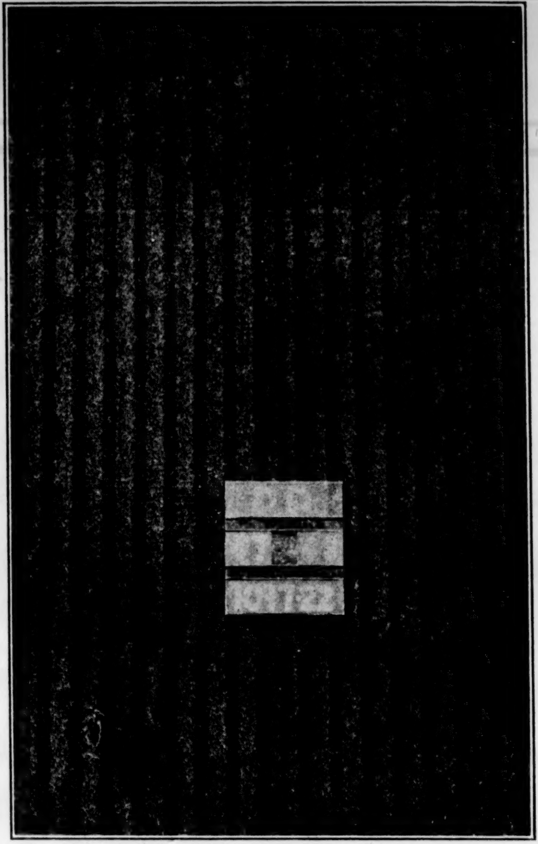

FIG. 20.—PITTSBURGH TESTS
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 47..	0.02	0.05	0.003	0.028	....	0.03	0.02
DD 48..	0.02	0.06	0.003	0.026	Trace	0.02	0.03

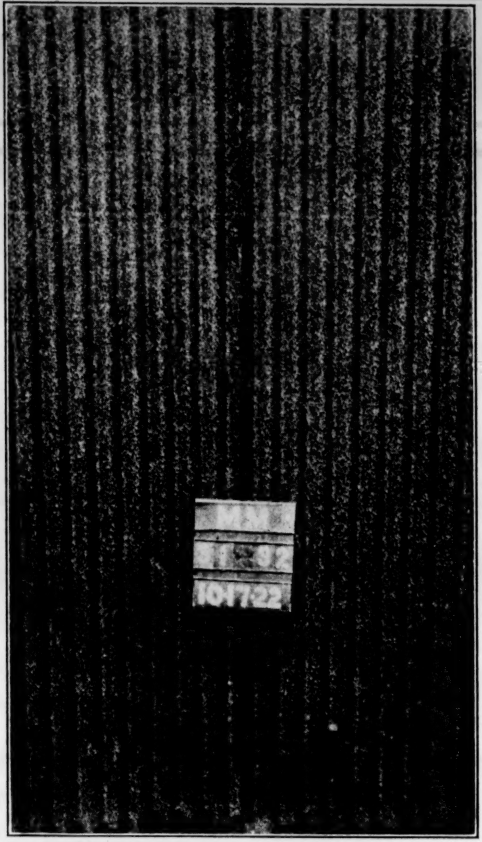

FIG. 21.—PITTSBURGH TESTS
No. 16 GAGE OPEN-HEARTH STEEL—SERIES B
ALAN WOOD IRON AND STEEL CO.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 31..	0.11	0.40	0.006	0.035	0.004	0.042	None
MM 32..	0.10	0.40	0.005	0.036	....	0.04	None

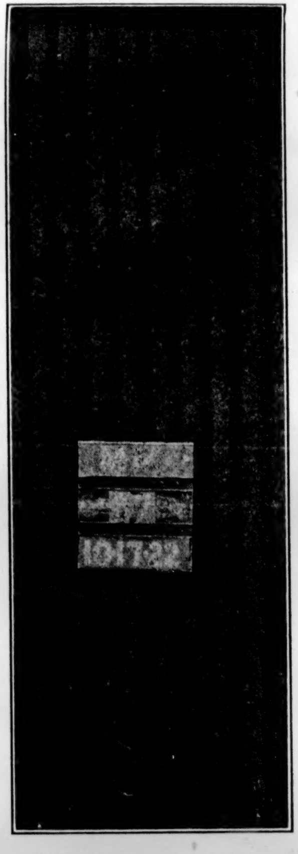

Fig. 22.—Pittsburgh Tests
No. 16 Gage Open-Hearth Steel—Series B
Alan Wood Iron and Steel Co.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 37..	0.11	0.46	0.011	0.031	0.004	0.045	None

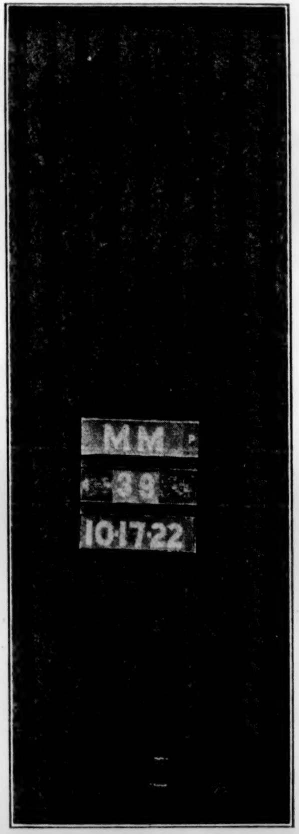

Fig. 23.—Pittsburgh Tests
No. 16 Gage Open-Hearth Steel—Series B
Alan Wood Iron and Steel Co.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 39.	0.105	0.42	0.011	0.031	0.005	0.050	None

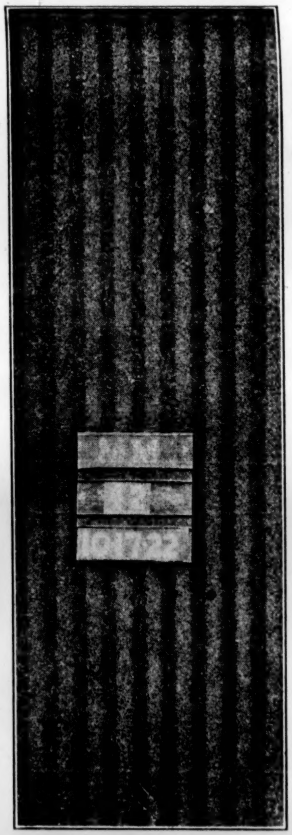

Fig. 24.—Pittsburgh Tests
No. 16 Gage Open-Hearth Steel—Series B
Alan Wood Iron and Steel Co.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
MM 42.	0.075	0.44	0.013	0.034	0.005	0.05	None

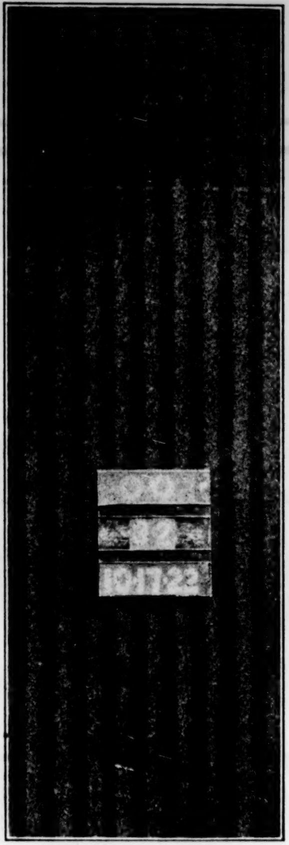

FIG. 25.—PITTSBURGH TESTS
No. 16 GAGE LOW-COPPER OPEN-HEARTH STEEL —SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
OO 32. .	0.11	0.38	0.006	0.026	0.005	0.028	Trace

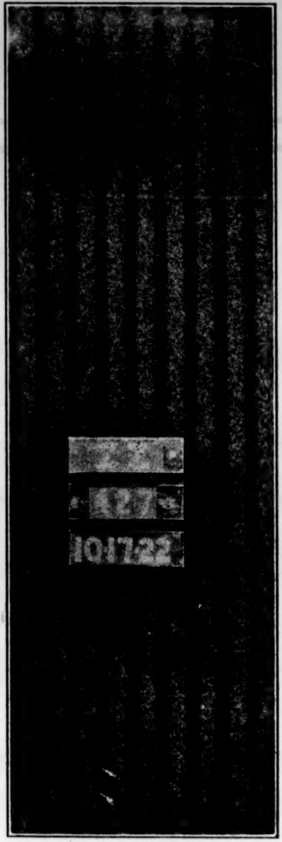

FIG. 26.—PITTSBURGH TESTS
No. 16 GAGE OPEN-HEARTH STEEL—SERIES B
YOUNGSTOWN SHEET AND TUBE CO.

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
ZZ 427.	0.023	0.40	0.044	0.028	....	0.032	....

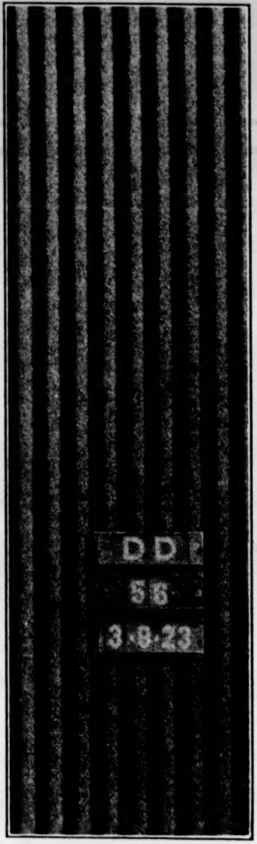

FIG. 27.—PITTSBURGH TESTS
No. 16 GAGE LOW-COPPER PURE IRON—SERIES A

Sheet	C.	Mn.	P.	S.	Si.	Cu.	Ni.
DD 56. .	0.01	0.02	0.005	0.028	....	0.022	....

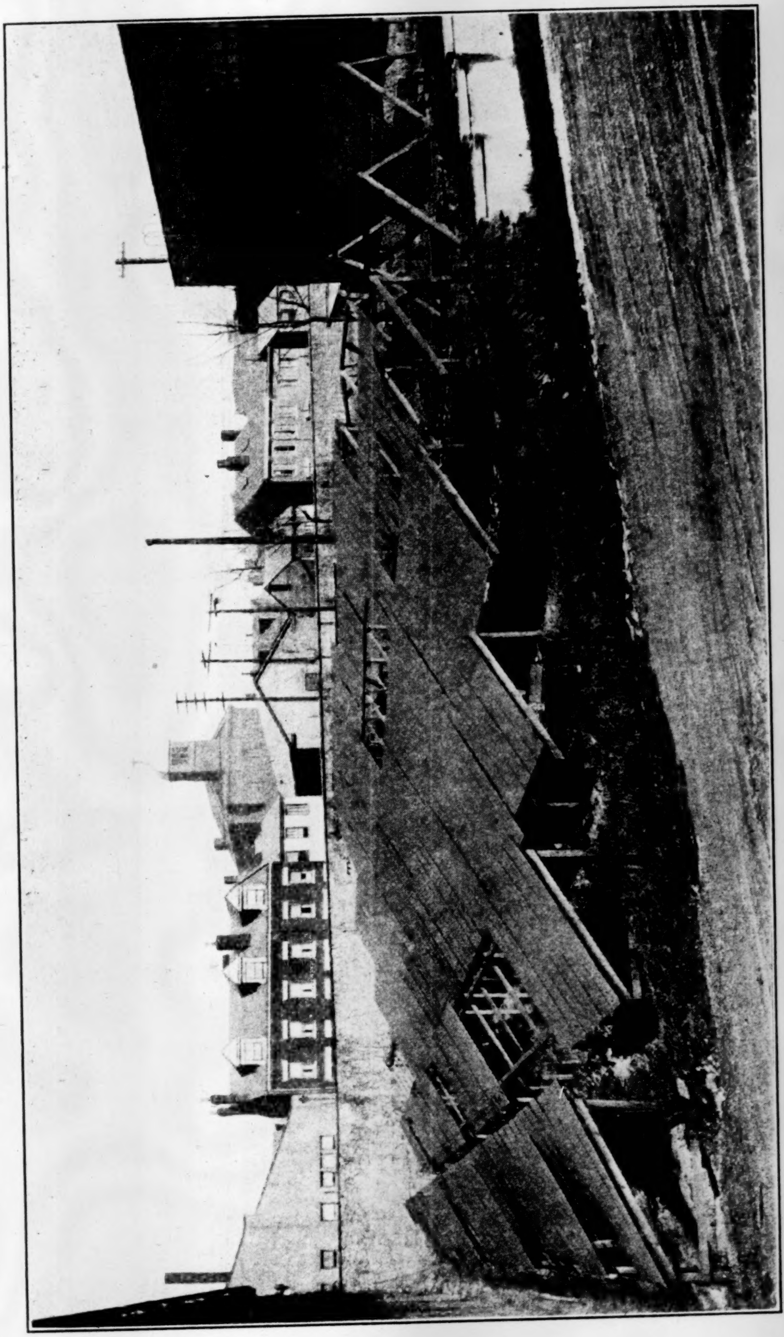

FIG. 28.—GENERAL VIEW OF PITTSBURGH TEST RACK, MARCH 9, 1923

REPORT OF SUB-COMMITTEE V ON TOTAL IMMERSION TESTS

Sub-Committee V reports that at the U. S. Bureau of Standards at Washington, D. C., 118 of the No. 22 gage specimens out of 144 have failed and that there has been no failure in the No. 16 gage specimens.

At the Naval Experimental Station at Annapolis, Md., 19 of the No. 22 gage specimens out of 144 have failed and that there has been no failure in the No. 16 gage specimens.

The sub-committee thinks it best not to make a detailed statement of the failures until all the No. 22 gage specimens have failed, but it is clearly demonstrated that copper added to the steel does not appear to be a factor in the life of the samples that are totally and continually submerged in running water. In this respect, the results are very different from the same material when exposed to the atmosphere.

Respectfully submitted on behalf of the sub-committee,

WILLIAM A. COOPER,
Chairman.

REPORT OF SPECIAL SUB-COMMITTEE ON METHODS FOR DETERMINING WEIGHT OF COATING ON IRON AND STEEL

The Special Sub-Committee on Methods for Determining Weight of Coating on Iron and Steel recommends that Committee A-5 publish, as a part of its annual report, the various methods used for determining the weight of coating on iron and steel. The sub-committee recommends that the hydrochloric acid - antimony chloride method as the standard method for determining the weight of zinc coating on iron and steel products and the basic lead acetate method and the sulfuric acid permanganate method as alternate methods be accepted for publication as tentative as appended hereto.[1] The sub-committee further recommends the publication as information of the various field methods for determining weight of zinc coating which are appended to the proposed tentative methods.

The following is extracted from the U. S. Bureau of Standards *Circular No. 80*:

> "The hydrochloric acid - antimony chloride and basic lead acetate methods are stripping tests and give the total amount of coating on a surface; the Preece test has been used to show thin spots and also, in a general way, the thickness of the coating. The lead acetate method may also be used to show thin spots, but used in this way is liable to show the same irregularities that led Committee A-5 of the American Society for Testing Materials to condemn the Preece test.[2]
>
> "The comparative value of the hydrochloric acid - antimony chloride and the basic lead acetate methods for stripping are discussed in the report of Committee A-5 for 1917,[2] and either method is considered satisfactory for sheet metal and wire, which were the materials tested.
>
> "The hydrochloric acid - antimony chloride method has been used at the U. S. Bureau of Standards almost entirely for stripping, because it removes the coating more quickly and can be applied to material of any shape and to all types of zinc coatings. The basic lead acetate method does not lend itself to irregular pieces, such as bolts, nuts, screws, etc., or parts with holes in them on account of the difficulty of removing the precipitated lead from the small depressions or holes and on account of the possible failure to react with sherardized coatings, which is also characteristic of the Preece test.
>
> "The hydrochloric acid - antimony chloride solution usually removes plated zinc completely in from 5 to 15 seconds and hot-dipped zinc in less than 30 seconds, but it has often been found that sherardized zinc is not completely removed during a 1-minute immersion—four immersions sometimes being required to remove all the coating."

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[1] See pp. 566-576.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XVII, Part I, p. 144 (1917).

The U. S. Bureau of Standards has also found that the hydrochloric acid - antimony chloride method of stripping is more accurate for the determination of zinc on electro-plated articles than the basic lead acetate method. This was shown by actually weighing samples of iron on which a definite amount of zinc was deposited; and after stripping them by the two methods, the results obtained showed that the lead acetate method yielded from 88 to 93 per cent of the actual amount of coating applied, while the hydrochloric acid - antimony chloride method yielded 100.7 to 101.4 per cent of the amount of zinc applied.

Respectfully submitted on behalf of the sub-committee,

J. A. AUPPERLE,
Chairman.

REPORT OF COMMITTEE A-6
ON
MAGNETIC PROPERTIES

Since the last revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel in 1918, a number of new methods for magnetic testing have been developed. In view of this fact, Committee A-6 has thought it desirable to revise the standard methods so as to permit the use of any method which yields results of satisfactory accuracy. A number of meetings of the committee have been held at which this revision has been carefully considered. The standard methods have been in continuous practical application since the revision of 1918, and in the light of the experience thus gained, a number of other modifications have also been made.

The methods now submitted for publication as tentative, as appended hereto,[1] as a revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 18),[2] permit the use of any method which yields results which are within the specified limits of accuracy. Reference methods are described by means of which the accuracy of permeameters shall be determined. The methods for core loss testing have not been materially changed.

This report has been submitted to letter ballot of the committee, which consists of 11 members, of whom 9 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. W. Burrows,
Chairman.

R. L. Sanford,
Secretary.

Editorial Note

The proposed revisions of the Standard Methods of Test for Magnetic Properties of Iron and Steel, referred to in this report, were accepted for publication as new tentative methods and appear on page 560.

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[1] See p. 560.—Ed.

[2] 1921 Book of A.S.T.M. Standards.

REPORT OF COMMITTEE A-8
ON
MAGNETIC ANALYSIS

While the individual members of Committee A-8 have carried out singly a number of important investigations in magnetic analysis, among which may be mentioned the testing of springs, welds, carbonized material, etc., which have been reported upon before the Society and elsewhere, the chief activity of the committee, since its last annual report, centers upon the work of its sub-committee on the testing of twist drills. This sub-committee was organized in 1920 for the purpose of carrying on an investigation looking toward a possible correlation of the magnetic and cutting properties of a definite tool made of high-speed steel of typical analysis. The particular tool finally selected was a twist drill.

A word might be said concerning the reasons for the selection of high-speed steel and of twist drills for investigation. In modern mass production high-speed tool steel plays an extremely important part, because of the high temperatures it will stand and which are incident to heavy cuts and feeds. The need of an inexpensive, rapid and reliable method of quickly testing such steels to show their cutting value is acute, but such tests as have been applied which are mechanical in nature have either not given satisfactory results or have been destructive in themselves. For the magnetic-mechanical examination of such steels, twist drills were selected as an example of an important article of manufacture and because their shape offered the least difficulties from the standpoint of the magnetic and mechanical testing required to establish the possible correlation. The type tested was a $\frac{1}{2}$-in. taper shank, made throughout of high-speed steel.

The following is abstracted from the report of the sub-committee:

> The stock from which the drills were made was specially rolled and chemically analyzed under the direction of a member of the sub-committee, whose company offered this as its contribution. The bars were then forwarded to the magnetic laboratory of the U. S. Bureau of Standards at Washington, D. C., where they were checked for uniformity from end to end, by magnetic means. The uniformity having been passed as satisfactory, the bars were shipped to a drill manufacturer who is represented on the sub-committee and whose contribution was the forming and heat-treatment of the drills. This same manufacturer also undertook the tests for hardness, micro-structure and

cutting properties which were carried out subsequent to the magnetic tests. The forming program included such variations in the dimensions of the stated product as are considered normal to production. A very wide range of heat treatment was represented, with a few instances where an open fire was used and pyrometric control was absent. To the list were added finally a few high-speed drills of an analysis very close to the others, as well as several carbon steel drills. In all, the drills numbered fifty-two.

The magnetic tests were carried out by five members of the sub-committee working more or less independently of each other, two of whom made tests by more than one method. So little has hitherto been done in the magnetic examination of high-speed steel, and there are so many magnetic criteria to serve as bases for tests, that it was felt that the initial work should be conducted as the best judgment of the individuals dictated. The experiments covered not only the equivalent of the formal and accepted methods of present-day magnetic testing, but also a number of tests under alternating magnetomotive forces which offered novel features. During the course of the tests the members of the sub-committee were kept informed through interchange of reports and in addition they met once for discussion of the tests so far completed and to plan the subsequent tests. In all, the magnetic examination embraced eight separate test procedures, planned with due regard to their adaptability in routine commercial testing.

Following the completion of the magnetic tests, the drills were returned to the drill manufacturer for examination as to micro-structure, hardness and cutting properties. The examination of the micro-structure has not been completed at the time of writing this report. Material for the purpose was cut from each drill before any cutting tests were started. The hardness of the drills has been measured under the Brinell, scleroscope and Rockwell tests. The tests for cutting properties consisted in drilling in four materials of widely differing characteristics and recording the total number of inches of penetration of each drill in each material. All tests were performed upon one drill press and by one operator. In each case the test was carried to the point where a drill refused to penetrate farther after which it was carefully machine ground for the next test. The materials used in the drilling were chrome die steel, heat-treated armor plate, a soft tough steel and cast iron. At the conclusion of the hardness and cutting tests, the members of the sub-committee were furnished with complete reports for study, and later met in New York City for discussion of the test results as a whole.

From the standpoint of a correlation of magnetic and mechanical characteristics, the test results so far obtained are to quite an extent negative in character but some promise is found in results obtained by one of the members under alternating magnetomotive forces, in which a distinction is apparently made between hysteresis and eddy current effects. In some instances the agreement is striking, and as the procedure employed seems capable of considerable refinement, it is the opinion of the sub-committee that the work should be continued. It is proposed to obtain a new lot of drills and to make further tests with special reference to the type of test mentioned above.

Committee A-8 desires to add to the foregoing that it considers the work thus far carried out but a survey to determine what appears to be the best method of approach to the solution of a problem of very considerable importance. High-speed steel was selected as the material for test, in the first place, because of its commercial significance and because the amount of endeavor necessary to establish a correlation, provided one exists, is so great as to demand a commensurate gain. For no single mechanical test has yet been found which will indicate completely the quality of this material. It is known, for example, that a certain degree of hardness, such as Brinell hardness, seems to be essential to a satisfactory tool, but a greater degree of hardness in a fairly wide range may be found in both good and bad tools. A quite large variation in heat treatment is possible with good results. The matter of establishing a criterion is complicated by the fact that it may be used under conditions, as with respect to temperature of cutting edge, impossible of accounting for in acceptance tests of a routine form, and that a drill which is very good for one grade of material may be comparatively poor on another. It appears from the results obtained by the sub-committee, so far as it has gone, that no single magnetic characteristic may be taken as indicative of the quality of the drill as a whole. It is felt possible, however, that a magnetic test procedure may be evolved which will take into account more than one physical property of the material and give at least a partial solution to the problem.

This report has been submitted to letter ballot of the committee, which consists of 14 members, of whom 11 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. P. FAHY,
Chairman.

R. L. SANFORD,
Secretary.

REPORT OF COMMITTEE B-1
ON
COPPER WIRE

At the annual meeting in 1922, Committee B-1 reported that at the request of the American Electric Railway Engineering Association the effort to arrive at specifications for copper trolley wire, acceptable to both societies, had been renewed with excellent prospect of ultimate success. Having in mind the successful outcome of this joint committee activity, Committee B-1 gave notice of its intention to recommend at the 1923 annual meeting the deletion from the Standard Specifications for Hard-Drawn Copper Wire (B 1 – 15)[1] of requirements covering exclusively trolley wire; the specifications as thus revised to continue as standard specifications for hard-drawn copper wire. The portions to be omitted are listed as a tentative revision of the standard specifications.[2] The desire of the A.E.R.E.A. that specifications for copper trolley wire be a separate and independent document was given as the reason for this action. The committee now recommends that the action, of which notice was given in 1922, be taken and that the specifications be published as standard in their revised form.

It affords great pleasure to be able to report complete agreement with the A.E.R.E.A. committee on Power Distribution on specifications for hard-drawn copper trolley wire. These specifications were drafted by the joint Conference Committee representing the two societies; they were considered at a meeting of Committee B-1 held on May 11, and unanimously accepted and referred to letter ballot of the committee. The specifications are appended to this report[3] with the recommendation that they be accepted for publication as tentative, due notice being given to the fact that they are the joint specifications of the A.E.R.E.A. and the A.S.T.M.

At the request of the large Sectional Committee on Insulated Wire and Cable, organized under the Rules of Procedure of the American Engineering Standards Committee, Committee B-1 has prepared specifications for soft annealed rectangular copper wire which were approved at a meeting of the committee held on May 11. The specifications are appended to this report[1] and it is recommended that they be accepted for publication as tentative.

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 198 (1922).

[3] See p. 577.—Ed.

Committee B-1 has also prepared specifications for hot-rolled copper rods which are used for wire drawing purposes. These were adopted at the meeting of May 11 and are appended to this report[2] with the recommendation that they be accepted for publication as tentative.

The joint Conference Committee, representing the Society and the A.E.R.E.A., is continuing its work on trolley wire with the expectation of working out mutually acceptable specifications on high strength alloy trolley wire, and it is hoped that such specifications may be presented for consideration next year.

The recommendations contained in this report have been submitted to letter ballot of the committee with the following results:

Item	For	Against	Not Voting
Submission of proposed revision of the Standard Specifications for Hard-Drawn Copper Wire (B 1–15)	10	0	0
Submission of proposed Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire	10	0	0
Submission of proposed Specifications for Soft Rectangular Copper Wire	9	0	1
Submission of proposed Specifications for Hot-Rolled Copper Rods for Wire Drawing	10	0	0

This report has been submitted to letter ballot of the committee, which consists of 10 members, of whom 10 have voted affirmatively, none negatively, and none have refrained from voting.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Hard-Drawn Copper Wire, as presented in 1922, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

The proposed Tentative Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire; for Soft Rectangular Copper Wire; and for Hot-Rolled Copper Rods for Wire Drawing, referred to in this report, were accepted for publication as tentative and appear on pages 577–586.

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[1] See p. 581.—ED.

[2] See p. 585.—ED.

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS

During the past year, no new specifications have been prepared by Committee B-2. A number of tentative standards are recommended for advancement to standard: namely,

- Tentative Specifications for Pig Lead (B 29 – 22 T)
- Tentative Specifications for Copper Pipe, Standard Sizes (B 42 – 22 T)
- Tentative Specifications for Brass Pipe, Standard Sizes (B 43 – 22 T)
- Tentative Methods of Chemical Analysis of Brass Ingots (B 45 – 22 T)
- Tentative Methods of Chemical Analysis of Bronze Bearing Metals (B 46 – 22 T)
- Tentative Methods of Chemical Analysis of Nickel (B 41 – 21 T).

Two new sub-committees have been formed during the year, Sub-Committee XI on Lead Pipe, Mr. W. A. Cowan, Chairman, and Sub-Committee XII on Metallic Fluxes and Deoxidizers, Mr. McKinney, Chairman.

The work of the committee can best be summarized by giving the reports of the various sub-committees which were accepted at the last meeting of the committee held on April 18. They were in substance as follows:

SUB-COMMITTEE I ON PURE METALS IN INGOT FORM

The sub-committee has discussed the matter of revising the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 4 – 13) and the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (B 5 – 13). No amendment is suggested at this time, but a special committee was appointed to go over the situation and make definite recommendations as to what action the committee should take in time to have the same placed before the Society at the annual meeting in 1924.

A special sub-committee was also appointed to consider and report methods for the sampling of copper.

An article on Tin, which will bring his previous article up to date, is being prepared by Mr. Lawrence Addicks. The sub-committee recommends that it be accepted by Committee E-6 on Papers and Publications for publication in the Proceedings as an appendix to the report of Committee B-2.[1]

The Tentative Specifications for Pig Lead (B 29 - 22 T)[2] are recommended for advancement to standard with the following revision:

Section 1.—Change from its present form: namely,

> "Virgin Lead is lead made from ore or similar raw material by direct processes of reduction and refining, and not produced from reworked metal, and is termed Pig Lead."

to read as follows:

> "These specifications are intended to cover lead in pig form, made from ore or similar raw materials, by processes of reduction and refining, and not produced from reworked material."

Section 2.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "Under these specification [Virgin Lead] *pig lead* is considered in three groups as follows:
>
> I. Corroding Lead
> II. Chemical Lead
> III. Common Lead."

SUB-COMMITTEE II ON WROUGHT METALS AND ALLOYS

Sub-Committee II has been engaged during the past year in revising the Tentative Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 - 22 T)[3] accepted at the last meeting of the Society.

The tubes employed in surface condensers of marine and stationary steam plants form a very vital part of the equipment and power engineers have quite rightfully endeavored to secure for this service the highest possible quality for this important adjunct. Opinion is quite unanimous that the so-called Admiralty mixture is best adapted for employment where severe service conditions are encountered. The endeavors of consumers to insure a high quality of this product has in the past resulted in the writing of a large number of specifications with this end in view. There has unfortunately, however, existed and still exists a quite lamentable lack of exact knowledge of the relationship between the various physical and chemical properties of a condenser tube and its ability to endure in service, with the result that unanimity of opinion as to the proper and necessary requirements for such specifications was wanting.

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[1] The paper by Lawrence Addicks, entitled "A Review of the Tin Situation," has been accepted for publication and appears on page 184.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 648 (1922).

[3] *Ibid*, p. 661.

In order to correct this situation, the specifications accepted as tentative at the last meeting of the Society were proposed by this sub-committee. Instead, however, of these specifications being generally accepted, the activity of independent specification writers has since then been more pronounced than ever, with the result that the burden imposed upon producing interests by the numerous conflicting requirements has become excessive.

It was felt that this condition was occasioned somewhat at least by an insufficient representation on the sub-committee of large consuming interests and in an endeavor to correct this situation, such representation was secured in the manner provided. As a result of the consideration of the matter by the sub-committee, as enlarged for this purpose, a number of amendments were submitted to the sub-committee. At the meeting of Committee B-2, held April 18, additional minor amendments were made. The specifications in their finally revised form are appended hereto.[1]

It is hoped that these specifications will be generally accepted in the interest of producers and consumers alike, to the end that the confusion incident to the present situation be avoided.

The matter of the preparation of specifications for copper wire rods was referred to the sub-committee, but it was upon consideration judged that this more properly came within the province of Committee B-1 on Copper Wire. It was accordingly voted to refer it to that committee.

The Tentative Specifications for Copper Pipe, Standard Sizes (B 42 – 22 T)[2] and for Brass Pipe, Standard Sizes (B 43 – 22 T)[3] are recommended for advancement to standard.

Committee B-2 recommends that the proposed revised Specifications for Admiralty Condenser Tubes and Ferrule Stock, referred to above and appended hereto,[1] be accepted for publication as a substitute for the present Tentative Specifications B 44 – 22 T.[4]

Sub-Committee III on Sand Cast Metals and Alloys

At the meeting of Committee B-2 held at the 1922 annual meeting of the Society it was decided that Sub-Committee III should investigate the subject of standard test bars for tensile and compressive tests on cast non-ferrous metals. Eleven manufacturers of cast materials, including the U. S. Bureau of Standards, have signified their willingness to make a series of comparative tests on a test bar, the requirements for which have been specified by the sub-committee. This test bar is represented in Fig. 1. Some of these manufacturers have already reported some of their results, but since they were made by the use of a test bar slightly different from that now recommended by the committee these tests are not reported. It is hoped that more detailed results will be available on this subject at the time the report of Committee B-2 is presented.

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[1] See p. 587.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 653 (1922).

[3] *Ibid*, p. 657.

[4] *Ibid*, p. 661.

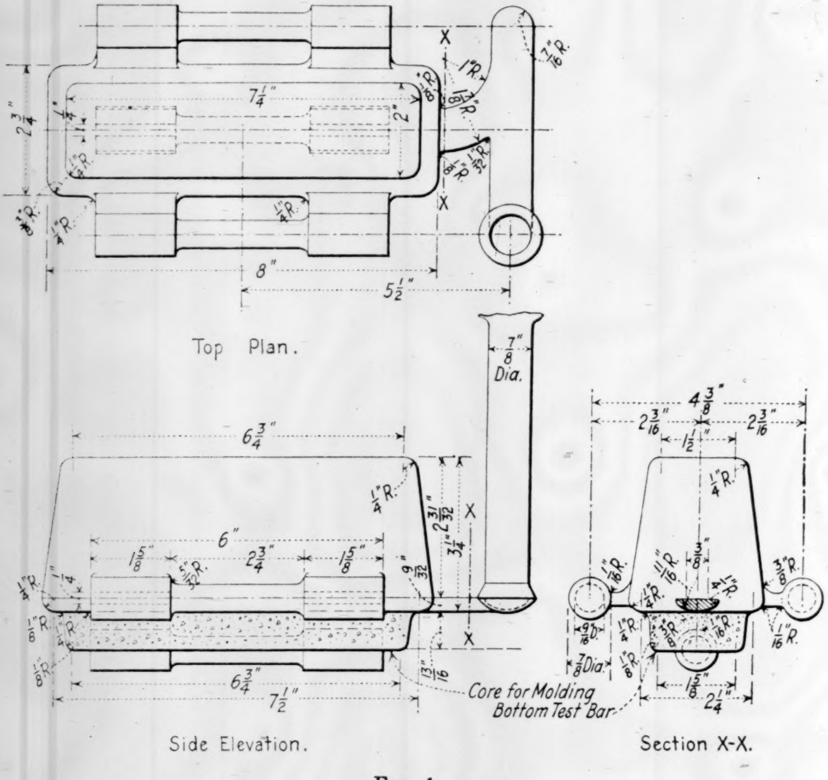
Top Plan.
7¼"
2"
2¾"
1"R.
7/16"R.
1/32"R.
1/4"R.
X
X
8"
5½"
7/8" Dia.
6¾"
6"
1⅝"
2¾"
1⅝"
5/32"R.
1/4"R.
2 31/32"
3¼"
9/32"
1/8"R.
13/16"
6¾"
7½"
Core for Molding Bottom Test Bar
Side Elevation.
4⅜"
2 3/16"
2 3/16"
1½"
1/4"R.
1/16"R.
11/16"R.
3/8"
3/8"R.
9/16"D.
7/8"Dia.
1⅝"
2¼"
Section X-X.

FIG. 1.

The subject of compression test coupons has also been considered but in view of the work that is now being carried on at the U. S. Bureau of Standards the committee deemed it advisable to await the results of the tests which the Bureau will shortly have available.

The subject of standard methods of sampling cast non-ferrous metals is also being considered and the committee will have a report to make on this during the coming year.

SUB-COMMITTEE IV ON WHITE METALS

At a meeting of Sub-Committee IV held during the 1922 annual meeting of the Society, it was pointed out that it would be desirable to determine the relative physical properties of babbitt metals made from virgin metals as compared with babbitt metals of the same formulas made from secondary materials, namely, drosses. It was pointed out that if a difference existed in the physical properties of the two classes of alloys, it was due to the contamination of impurities. The detrimental impurities were listed at that meeting, and a definite program mapped out whereby the physical properties of alloy No. 1 and alloy No. 7, containing the listed impurities, would be compared.

George K. Burgess and J. R. Freeman, of the U. S. Bureau of Standards, were in attendance at the meeting and volunteered that the Bureau would undertake the proposed investigation. In reply to an inquiry by the chairman as to the progress of the work in the Bureau, Mr. Burgess advised that the work is not yet completed but it is hoped that it will be finished in time for presentation at the annual meeting of the Society. At the same time the results of an extensive investigation on the effect of the ratio of length to diameter in compression testing of babbitt metal will be presented.

The sub-committee recommends that the present Tentative Specifications for White Metal Bearing Alloys (B 23 – 18 T) be continued as tentative.

SUB-COMMITTEE V ON PLATES, TUBES AND STAYBOLTS FOR LOCOMOTIVES

The question of revising the elongation requirements in the Standard Specifications for Copper Plates for Locomotive Fireboxes (B 11 – 18) and the Standard Specifications for Copper Bars for Locomotive Staybolts (B 12 – 18) was brought up at the meeting of the committee on April 18. The committee had included in its report last year the results of certain tests of copper plates and bars for staybolts. In the discussion which followed it was brought out that elongations of 40 per cent for firebox sheet and 45 per cent for staybolt rod were easily obtained if the copper were annealed after it had been received from the manufacturer. The matter was therefore again referred to the sub-committee for further consideration.

SUB-COMMITTEE VI ON NON-FERROUS ALLOYS FOR RAILROAD EQUIPMENT

The specifications of the Society for non-ferrous alloys for railroad equipment are little used in this country. They are, however, being used to some extent by the foreign purchasers of railway equipment.

Specifications covering non-ferrous alloys for railway equipment were adopted a few years ago by the American Railway Association. These specifications are becoming more and more used, so that to-day there is a real tendency on the part of the majority of our railway systems to purchase under the A.R.A. specifications. Several of the large trunk lines, however, continue to use their own specifications.

Suggestion has been made from time to time that a joint committee of the A.S.T.M. and the A.R.A. be organized to consider the subject of uniform specifications to be adopted by both associations. The chairman recently had a conference with F. M. Waring, Chairman of the Metal Division of the A.R.A., and he advises that his Association is at present considering making changes in their specifications at the coming annual meeting in June. If such changes are adopted, the A.S.T.M. specifications and the A.R.A. specifications will be brought into closer relationship, and the chairman believes that there should be no particular difficulty in harmonizing the two specifications if a joint A.R.A.-A.S.T.M. Committee were organized having that purpose in view.

It is recommended that the present Tentative Specifications for Non-Ferrous Alloys for Railway Equipment (B 17 - 18 T) be continued as tentative.

SUB-COMMITTEE VII ON METHODS OF CHEMICAL ANALYSIS

The sub-committee recommends a revision of the Standard Methods of Chemical Analysis of Pig Lead (B 35 - 20),[1] which consists in the addition of a special method for the determination of small amounts of zinc on a separate portion of the sample. The present method for zinc and manganese given in the General Method is to be omitted. The proposed revision is appended[2] hereto and Committee B-2 recommends it be accepted for publication as tentative.

On further study of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 21 T),[3] only slight changes relating to the determination of non-graphitic and graphitic silicon, and to the determination of manganese by the persulfate method have been considered. These changes are of the nature of corrections and are as follows:

Change the second paragraph under "Notes" on page 500 of the 1921 Proceedings from its present form: namely,

> "Graphitic silicon is not oxidized to silica by the solution or ignition treatments and therefore resists the action of HF and H_2SO_4. Graphitic silicon is, however, readily attacked and volatilized by a mixture of HNO_3 and HF."

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 594.—ED.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 499 (1921).

to read as follows:

"Graphitic silicon is only slightly and slowly oxidized to silica by the solution or ignition treatments, and to the extent in which it is not oxidized, it resists the action of HF and H_2SO_4. Graphitic silicon is, however, readily attacked and volatilized by a mixture of HNO_3 and HF. On account of the possibility of slight oxidation of graphitic silicon by the treatments involved in the method, the latter may not be absolutely exact, but it is the best that has been devised."

Change the paragraph on "Method" under the "Determination of Manganese" on page 505 of the 1921 Proceedings from its present form: namely,

"In a 250-cc. Erlenmeyer flask, dissolve 0.5 g. of the sample in 25 cc. of H_2SO_4 (1 : 1) by warming and adding a drop or two of HNO_3 (sp. gr. 1.42) occasionally until solution is complete. Boil until oxides of nitrogen are expelled. Dilute with hot water to 200 cc. When the solution is boiling add 20 cc. of $AgNO_3$ solution and 30 cc. of the persulfate solution. Boil not less than one minute nor more than 2 minutes. (Instead of boiling, the solution may be left on the steam bath until it has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion.) Cool to below 25° C. in running water, and add 50 cc. of cold water. Titrate with the standard arsenite solution to the disappearance of the pink color."

to read as follows:

"In a 250-cc. Erlenmeyer flask, dissolve 0.5 g. of the sample in 25 cc. of H_2SO_4 (1 : 1) by warming and adding a drop or two of HNO_3 (sp. gr. 1.42) occasionally until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 cc. with boiling hot water, remove the flask from the flame, add 20 cc. of $AgNO_3$ solution, and then 30 cc. of the persulfate solution. Let the solution stand on the steam bath until it has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color."

Add a paragraph under "Note" on page 506 of the 1921 Proceedings, to read as follows:

"The ammonium persulfate must be tested for its strength. A good grade should contain about 95 per cent of $(NH_4)_2 S_2O_8$; some lots contain no more than 25 per cent of the salt."

Insert a sentence in the paragraph on "Method" under the "Determination of Magnesium" on page 514 of the 1921 Proceedings, immediately preceding the sentence reading "Filter and wash with the $(NH_4)_2S$ wash," to read as follows:

"Let the solution stand for about two hours at a temperature of approximately 40° C. (at the side of the steam bath)."

Committee B-2 recommends that the methods be revised as indicated and that the methods, as revised, be continued as tentative.

The sub-committee expects to give consideration to methods for determination of small quantities of aluminum, tin and bismuth in zinc, to be forwarded by the International Committee on Standardization of Zinc.

The sub-committee recommends that the following tentative methods be advanced to standard:

Tentative Methods of Chemical Analysis of Nickel (B 41 - 21 T).[1]

Tentative Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 - 22 T).[2]

Tentative Methods of Chemical Analysis of Bronze Bearing Metals (B 46 - 22 T).[3]

SUB-COMMITTEE VIII ON ALUMINUM ALLOYS, CAST AND WROUGHT

The sub-committee recommends that the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (B 24 - 22 T), for Aluminum Sheet (B 25 - 19 T) and for Aluminum for Use in the Manufacture of Iron and Steel (B 37 - 20 T) be continued as tentative for another year, because changes in all of them are contemplated.

Mr. J. L. Jones has resigned as chairman and Mr. E. Blough has accepted appointment in his place.

SUB-COMMITTEE IX ON NOMENCLATURE OF METALS AND ALLOYS

During the past year, no criticisms or comments have been received on the sub-committee's report for 1920. With the publication by the Society of the extensive List of Alloys compiled by William Campbell, the great difficulties in the way of a logical and scientific classification and nomenclature become very apparent. The metal industry is very conservative and dislikes radical changes and will continue to call high-strength brasses by such names as "manganese bronze," in spite of the fact that they are not bronzes and many of them contain no manganese.

During the coming year, work on the classification will be continued. Mr. E. L. Lasier has accepted the chairmanship in place of W. B. Price.

SUB-COMMITTEE X ON METHODS OF TESTING

The sub-committee is working on compression tests of sand-cast metals and alloys, and of white metals. Investigations have been carried out at the U. S. Bureau of Standards and the results of this work will be presented at the approaching annual meeting as a paper by J. R. Freeman, Jr., and P. F. Brandt, entitled "The Influence of the Ratio of Length to Diameter in the Compression Testing of Babbitt Metals."[1] As the matter is also being taken up by Committee E-1 on Methods of Testing, definite recommendations may be expected next year.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 522 (1921).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 664 (1922).

[3] *Ibid.*, p. 674.

The analysis of the letter ballot of the committee is as follows:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS IN TENTATIVE STANDARDS			
1. For Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 - 22 T).........	34	0	63
2. Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 21 T)	45	0	52
II. PROPOSED REVISIONS IN STANDARDS			
3. Methods of Chemical Analysis of Pig Lead (B 35 - 20).........................	42	0	55
III. TENTATIVE STANDARDS TO BE ADOPTED AS STANDARD			
4. For Pig Lead (B 29 - 22 T)...	36	0	61
5. For Copper Pipe, Standard Sizes (B 42 - 22 T)............................	35	0	62
6. For Brass Pipe, Standard Sizes (B 43 - 22 T).............................	42	0	55
7. Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 - 22 T).....	43	0	54
8. Methods of Chemical Analysis of Bronze Bearing Metals (B 46 - 22 T)............	41	0	56
9. Methods of Chemical Analysis of Nickel (B 41 - 21 T)........................	41	1	55

This report has been submitted to letter ballot of the committee, which consists of 97 members, of whom 53 have voted affirmatively, none negatively, and 44 have refrained from voting.

Respectfully submitted on behalf of the committee,

P. D. MERICA, WILLIAM CAMPBELL,
Secretary. *Chairman.*

EDITORIAL NOTE

The Tentative Specifications for Pig Lead amended as indicated in the report; the Tentative Specifications for Copper Pipe, Standard Sizes; for Brass Pipe, Standard Sizes; and the Tentative Methods of Chemical Analysis of Brass Ingots and Sand Castings; of Bronze Bearing Metals; and of Nickel, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

The proposed revisions of the Standard Methods of Chemical Analysis of Pig Lead were accepted for publication as new tentative methods and appear on page 594.

The proposed revisions of the Tentative Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock; and of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys were accepted. The tentative standards as thus revised appear on pages 587 and 597, respectively.

For a discussion of this report, see page 188.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 150 (1923).

APPENDIX

A REVIEW OF THE TIN SITUATION

By Lawrence Addicks

A specification to be generally adopted must reasonably reconcile the inherently different points of view of producer and consumer. This requires a classification of the material which will allow the producer to market everything produced and the consumer to choose the grade suitable for his particular work, paying accordingly. It is obviously necessary to understand the situation from both sides when a specification is to be drawn up and this providing of a common ground is one of the chief functions of this Society.

In the case of tin, this mutual understanding is wholly lacking at the present time, due chiefly to the great geographical distance between the points of production and consumption and the speculative basis on which tin is handled by a broker as a middleman. This brief review is once more offered after investigation by the committee as a revision of that presented by the committee in 1916[1] instead of a formal specification because it is believed that the time has not yet arrived when even the foundation of a specification can be laid.

Ores.—Practically speaking, there is but one ore of tin, cassiterite, which in some cases is almost pure stannic oxide. It occurs as "vein tin" in mineral lodes and as "stream tin" in alluvial deposits. Vein tin is generally associated with other minerals, while stream tin is much purer.

Geographical Distribution.—Tin is found in paying quantities in very few places. The relative importance of the sources may be judged by their approximate outputs, stated below in long tons of metallic tin per annum.

Straits	40,500	long tons
Bolivia	30,000	"
Banka and Billiton	17,000	"
Cornwall	2,000	"
Australia	3,000	"
China	10,000	"
South Africa	2,000	"
Belgian Congo	1,800	"
Miscellaneous	2,500	"
	108,800	"

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XVI, Part I, p. 187 (1916).

The Straits tin comes from Penang, Singapore and Malacca, the two latter being towns on the Malay Peninsula and the former an island off the west coast and in English hands. Banka and Billiton are islands in the Dutch East Indies.

Metallurgy.--The metallurgy of tin is very simple in the case of the pure deposits. The ores, which run but a few tenths of one per cent in tin, are readily concentrated by ordinary wet methods to a 60 to 70-per-cent product, on account of the high specific gravity of cassiterite. The concentrate is smelted in a reverberatory furnace with coal as a reducing agent and the fluxes necessary to slag the remaining gangue. The resulting crude tin is them refined by liquating and drossing. As stannic oxide is difficult to reduce, the various impurities present are also reduced and largely collected in the crude tin from which they can be but imperfectly removed by liquation. The result is that the purity of the final product depends largely upon that of the original tinstone, so that certain deposits have come to have a reputation as producers of high-grade tin.

The growing importance of Bolivia as a producer, coupled with the considerable quantities of impurities, notably bismuth, antimony and lead, caused the development of an electrolytic process about ten years ago. This has been entirely successful and electrolysis, of course, obliterates the past history of the crude tin. Improvements were then added to the older fire process, consisting principally of salt roasting and leaching applied to the concentrates and an elaboration of the liquation and drossing steps. While this does not eliminate impurities as readily as the electrolytic method, it does result in making a product which, if not usable direct, may be blended with other tin of high purity in order to meet the requirements of Standard Tin.

Market.—It has been the fixed policy of the Dutch and English colonies to smelt the tin concentrates at the point of production, export duties having been imposed on tin ores. Prior to the war, the Bolivian concentrates were sent to England and Germany, where they were worked into a low-grade tin. Then for a time they came chiefly to the United States, on account of the development here of the electrolytic process. Then the fire process was also established in this country, but within the last year it has become evident that the treatment of tin concentrates in America can no longer be profitably carried on in the face of European competition, and the various American plants are shutting down. There has been a certain amount of agitation for an import duty on refined tin entering this country but it is, of course, opposed by tin plate manufacturers, who are doing a large export business, and at the present writing there seems small probability of a revival of the tin smelting industry.

According to the rules of the London Metal Exchange, tin is merchantable as Standard Tin only when the warrant is accompanied by analysis certifying that the metal contains either 99.00 or 99.75 per cent of pure tin, according to whether the quality is that of common tin or refined tin, and also that it is of the correct physical condition.

Straits, Australian, English Refined, Banka, and Billiton fall within the highest class, namely, refined tin. The Chinese tins are "off-grade," carrying considerable lead, and the German tins resulting from the smelting of Bolivian concentrates are likely to be foul. The worst of them will run over 90 per cent of tin, while the high-grade tins will run 99.8 to 99.9 per cent. The only tests required for good merchantable tin aside from its origin are that it shall run at least 99.75 per cent of tin and that a bar when nicked and bent double shall not crack.

TABLE I.—ANALYSES OF DIFFERENT BRANDS OF TIN

Elements	Electrolytic	Straits, Banka, Billiton	Australian	English Common	English Refined	German	Chinese	Bolivian[1]
Tin, per cent	99.91	99.80–99.95	99.75–99.90	99.2	99.9	99+	95–99	93
Antimony, per cent	0.006	0.02	0.04	0.25	0.04	0.65	0.02–0.40	4.0
Arsenic, per cent	0.005	0.04	0.06	0.06	0.05	....	0.06	0.2
Bismuth, per cent	0.03	none	0.003	0.06	0.001	....	0.01	0.1
Copper, per cent	0.03	0.01	0.04	0.08	0.015	....	0.09	0.5
Iron, per cent	.....	0.03	0.03	0.004	0.002	....	0.15	0.02
Lead, per cent	0.005	0.02	0.04	0.36	0.01	0.14	0.3–4.0	2.7
Zinc, per cent	none	0.03	none	0.006	0.01	....	none	0.03

[1] No longer sold unrefined, but analysis is given to show impurities. Bismuth is increasing with depth of mining

Analyses.—The consumer generally meets the situation in which he finds himself by buying a first-class brand, analyzing it when he gets it, and then sorting the lots by analysis for certain uses. It is of doubtful value to give here a long list of analyses of different brands, but a rough idea of the various grades given in Table I will illustrate the situation.

Uses.—The principal uses of tin, aside from tin salts and pigments, are as metal in pipe, fusible boiler plugs, etc.; as a coating, as in tin plate, tinned wire, tin-lead foil, etc.; and in an alloy, as in bronze, babbitt, solder, britannia metal, type metal, fusible alloys, etc. The bronzes are alloys with copper and zinc; babbitt metal with antimony and copper; solder with lead and a little antimony; britannia metal with antimony; fusible alloys with lead, bismuth and cadmium.

Allowable Impurities.—The impurities in tin may cause trouble by poisoning, as in the case of pipe and tin cans; by impairing fluidity, causing an excessive consumption of tin used for coating, or making solder hard to apply; by fouling an alloy and spoiling its appearance;

by impairing the ductility of alloys which have to be worked, such as bronze or britannia metal; by causing local galvanic action and possibly "tin pest"; and by affecting the melting point of fusible alloys.

In a general way the purest obtainable tin is desired for pipe and boiler plugs. The U. S. Bureau of Standards has found that zinc, generally introduced by a foul pot when remelting tin, causes serious deterioration in boiler plugs and recommends as nearly as possible absolute freedom from zinc and lead.

One of the tin-plate manufacturers states that lead makes a mottled finish, iron causes a rough surface and impairs fluidity, and arsenic and zinc tend to form poisonous salts. They suggest maximum allowable percentages as follows:

Lead	0.04	per cent
Copper	0.02	"
Iron	0.05	"
Arsenic	0.05	"
Antimony	0.02	"
Zinc	0.05	"

One of the manufacturers of wrought bronze gives the following maximum allowable percentages:

Antimony	0.01	per cent
Bismuth	0.001	"
Lead	0.05	"
Iron	0.05	"

DISCUSSION[1]

Mr. Patch

MR. N. K. B. PATCH.[2]—The test bar referred to in the committee's report is proposed at this time merely for criticism, with the thought that it would be a step that might lead to definite results later on. We have so far a large number of tests which indicate that there is real promise of the bar being a successful standard. The question of the volume of the riser head in the middle of it suggests the possibility of a more economical design, but as a beginning it is intended to have it large enough so that there will be no doubt about feeding the bars.

Mr. Dix

MR. E. H. DIX, JR.[3]—I should like to make one comment in regard to this matter. I think the committee should consider that by adopting this as a single standard for all non-ferrous alloys, they are adopting a method which may be more complicated than is necessary for certain of the alloys. I have in mind particularly, aluminum alloys. Most of the aluminum alloys are very easy to cast in the form of test bars. Uniform results may be secured by very simple methods. By using the method recommended by the committee, the test bar is joined to the riser by means of gates along the shank of the test bar. This means that it cannot be pulled in a wedge grip without machining, and machining adds to the cost of the test bar and causes a loss in time between the casting of the bar and the testing. I know that Mr. Patch has this in mind, but I should like to emphasize this danger in attempting to go too far in the matter of standardization. I do not see that there is any advantage in using the same test bar for aluminum alloys as for manganese bronzes, for instance.

Mr. Patch

MR. PATCH.—Before anything is done about standardizing test bars which would apply to aluminum alloys, we should have to work with the sub-committee having those alloys in charge, and no doubt they will bring that very point to bear.

Mr. Hance

MR. J. A. HANCE.[4]—It is very important that the test bar recommended by the Society should fairly represent the lot of castings from

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[1] The discussion of the paper on "Methods of Casting Test Specimens of Gun Metal" by E. H. Dix, Jr., contains several references to the report of Committee B-2, and should be consulted. See *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 141 (1923).—ED.

[2] Works Manager, Lumen Bearing Co., Buffalo, N. Y.

[3] Metallurgist, Research Bureau, Aluminum Co. of America, New Kensington, Pa.

[4] Baldwin Locomotive Works, Philadelphia, Pa.

Mr. Hance

which it is taken. We made nine heats of material to the Specifications for Bronze Bearing Metals (B 22 – 21), Class D, in which every precaution was taken to make the best castings obtainable. The tests made from the special test bars called for in the specifications show a tensile strength of from 45,000 to 50,000 lb. per sq. in., while test bars taken from various parts of the castings show tensile strength of from 23,000 to 27,000 lb. per sq. in. Experienced inspectors will not accept tests made from bars cast in this manner.

Mr. Campbell

MR. WILLIAM CAMPBELL[1] (*Chairman, Committee B-2*).—Referring to the remarks of the last speaker: Some years ago Mr. L. P. Webert published some results in this Society which were apparently astounding, covering the alloy gun metal.[2] He poured the test bars at different temperatures from the lowest to the very highest, and strange to say the bars poured at the very lowest temperature gave, I think, about 54,000 lb. tensile strength and well over 50 per cent elongation; and yet as I remember it, our standard specifications call for minimum tensile strength of 30,000 lb. per sq. in. and minimum elongation of 14 per cent. Now the reason we do not call for 40,000 lb. per sq. in. tensile strength and say 25 or 30 per cent elongation is because the majority of foundries cannot produce a sound test bar. I need hardly say what happens to the castings. Now perhaps you will think that statement is somewhat far fetched, but during the World War the Government bought a great many gun-metal castings. Inspection showed that they did not pull 30,000 lb. per sq. in., and then we had this argument, that the test bar was not representative of the casting —not that the test bar gave too high a test, but the test bar gave too low a test! In order to show up that argument, a number of valves and other castings were cut open, and the interior fitted that definition which somebody gave in one of the meetings of the sub-committee on steel castings: that is, that "a casting was a number of holes held together by membranes of metal." Now at the Navy Yard, New York, if the ordinary test bar attached to castings does not pull 35,000 to 40,000 lb. per sq. in. and has an elongation of 20 to 30 per cent, the casting is looked upon with a great deal of suspicion, to say the least. I think the sooner we get it into our heads that the tension test specimen represents the quality of the casting of the same thickness, the better. It does not and can not represent the quality of the casting which is thicker or thinner than the test bar. Moreover, any casting, no matter what size, that is spongy in the interior, is faulty.

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[1] Professor of Metallurgy, School of Mines, Columbia University; and Metallurgist, New York Navy Yard.

[2] L. P. Webert, "Study of the Strength of Non-Ferrous Castings: Comparison of Different Test Specimens," *Proceedings*, Am. Soc. Testing Mats., Vol. XIV, Part II, p. 145 (1914).

The President

THE PRESIDENT (MR. GEORGE K. BURGESS).[1]—If the chair may enter into the discussion, I was very much interested in Mr. Addicks' paper regarding tin, and his statement that he thought the time was not yet ripe for tin specifications. As I heard his paper, it struck me that, on the contrary, apparently tin may be divided easily into three groups, at least chemically: certainly the large tonnage production falls into the group which is 99.75 per cent tin or better, according to his statement, and most of the rest of it into 99.0 per cent, and a single electrolysis of the 99.75 will give easily 99.99 per cent. It is a matter of passing interest that double electrolytic refining of Bolivian tin, which I understand is the foulest of all, will give 99.99 per cent tin and that this tin is used and has been used by the U. S. Bureau of Standards as its standard for melting point determinations and chemical analysis. On Mr. Addicks' showing, therefore, I frankly consider that there is a very good basis for setting up chemical specifications which will be in accord with commercial practice.

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[1] Director, U. S. Bureau of Standards, Washington, D. C.

REPORT OF COMMITTEE B-3

ON

CORROSION OF NON-FERROUS METALS AND ALLOYS

Committee B-3 was organized in 1922 for the purpose of inproving the technique of corrosion testing of non-ferrous metals and alloys, of standardizing it so far as possible, and possibly later of assembling standard data on the corrosion resistance of different non-ferrous materials.

It was recognized at the outset by the committee that the types and conditions of corrosion of commercial interest are varied and numerous, and that in consequence the technique of the determination of corrosion-resistance of metals and alloys was different in almost every laboratory. Also, the results obtained under supposedly similar conditions varied, due to the fact that the limit of error of the various methods used was not recognized.

It was decided, therefore, that the committee would do no work of research into the mechanism of corrosion, but would limit its activities, for the present at least, to the work of developing standard corrosion tests and determining their necessary conditions and their accuracy.

As a first step in its activity the committee authorized the circulation of a questionnaire to its own members and all others interested in the subject and having practical knowledge of it. This questionnaire was to elicit not only detailed information from each individual regarding his practice and experience in corrosion testing but also his opinion as to the best practice in these details. In addition, a general opinion was sought as to the direction which the further activities of the committee should take; in other words, in what manner and form can the experience of its members be best organized to improve the practice of corrosion testing and to increase our accurate knowledge of the corrosion-resisting properties of non-ferrous metals and alloys.

About 200 questionnaires were sent out and about 40 replies were received of which only 18 or 20 offered any particular comments on the questionnaire and of these only 10 really replied in detail. At a meeting of Committee B-3 held on April 19, 1923, a sub-committee appointed to handle the questionnaire reported it would not be able to draw up its report and propose any specific standard methods of corrosion testing for some few months, but it is possible that a report representing considerable progress may be made at that time.

This report has been submitted to letter ballot of the committee, which consists of 31 members, of whom 26 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

E. C. LATHROP,
Chairman.

SAM TOUR,
Secretary.

REPORT OF COMMITTEE C-1
ON
CEMENT

Although Committee C-1 on Cement has had two meetings since the last annual meeting, it has not succeeded in reaching conclusions on enough of the questions being considered to warrant making at this time specific recommendations on its tentative specifications.

The Tentative Specifications and Tests for Compressive Strength of Portland Cement Mortars are the main subjects under consideration. Committee C-1 is depending on its Sub-Committee on Strength to make recommendations that will help the committee to come to the final conclusions that may be presented to the Society. The subject matter is so important and the mass of data so large that the sub-committee has been unable to complete its research. Because of this, Committee C-1 can not make definite recommendations on these specifications at this time as had been hoped that it might do.

Committee C-1 has found that several phases of cement specifications are still open questions and has made recognition of these questions by submitting them to various sub-committees for their consideration. Notable among these are the questions of a study of the Specifications for Natural Cement.

In connection with the committee's plan to try to arrange for research work in investigating the qualities of and what constitutes portland cement, as well as a study of the effects of admixtures upon cement, the committee would report that such research work is under way although not directly under the supervision of Committee C-1 but with its endorsement.

The plan of the committee to father the publication of a handbook to explain and emphasize facts regarding the methods used in making the tests and analyses as specified is progressing and it is hoped that this hand-book will be the means of emphasizing the standard methods in a way that they should be used in the many laboratories making these tests.

This report has been submitted to letter ballot of the committee, which consists of 55 members, of whom 41 have voted affirmatively, 1 negatively and 13 have refrained from voting.

Respectfully submitted on behalf of the committee,

Russell S. Greenman,
Chairman.

R. B. Young,
Secretary.

REPORT OF COMMITTEE C-3
ON
BRICK

Last year, the Conference on Elimination of Unnecessary Sizes and Types of Paving Brick, organized by the U. S. Department of Commerce, recommended the reduction of the then existing 66 sizes and types of paving brick to seven, and appointed a permanent committee to take future jurisdiction over this matter. This year, this committee recommends the elimination of one more, leaving the following six as the recognized sizes and types of paving brick:

	Width, in.	Depth, in.	Length, in.
Plain wire-cut brick (vertical fiber, lugless)	3[a]	4[a]	8½
" " " " " "	3½[a]	4[a]	8½
Repressed lug brick	3½	4	8½
Wire-cut lug brick (Dunn)	3½	3	8½
" " " "	3½	3½	8½
" " " "	3½	4	8½

[a] These bricks are customarily laid in the pavement to give a depth of 3 in. and 3½ in., respectively, by 4 in. in width by 8½ in. in length.

The sizes stated above are to be regarded as nominal and subject to the usual variation of ⅛ in. in width and depth and ½ in. in length.

Committee C-3 recommends that the action of the Conference be formally approved by the Society and the six recognized sizes mentioned above be published as an appendix to the standard specifications for Paving Brick (C 7 – 15),[1] superseding the recommendation made by the committee in 1922.[2]

While some criticism has been received of the Tentative Specifications for Clay Sewer Brick (C 32 – 21 T),[3] the committee has decided to make no change. It is therefore recommended that these specifications be advanced to standard. The letter ballot of the committee on this recommendation resulted as follows: Affirmative, 14; negative, 3; not voting, 6.

The preparation of specifications for concrete brick depends upon obtaining further experimental data about the properties of this material. This work has been under way in several laboratories throughout the year.

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 986 (1922).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 527 (1921).

Much information of value has been obtained by studying the demolition of old buildings and noting the condition of the materials after years of service. Thus far, it has been possible to conduct this investigation only casually, by individuals. It is believed that the study is worthy of organized effort, and that the results would be of interest to many other committees of this Society. The attention of the Executive Committee has therefore been called to this matter.

This report has been submitted to letter ballot of the committee, which consists of 23 members, of whom 21 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

T. R. LAWSON,
Chairman.

W. E. EMLEY,
Secretary.

EDITORIAL NOTE

The recommendation contained in this report on the inclusion of 6 recommended sizes for paving brick in the Standard Specifications for Paving Brick was accepted and appears on page 963.

The Tentative Specifications for Clay Sewer Brick were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

REPORT OF COMMITTEE C-4

ON

CLAY AND CEMENT SEWER PIPE

Committee C-4 has held two meetings, both well attended, since the last annual report.

The matters now principally engaging the attention of the subcommittee are briefly:

Sub-Committee I on Sampling and Physical Test Requirements is considering the possibility of making certain tests at the factory and is giving further study to physical test requirements and to sampling.

Sub-Committee II on Chemical Requirements is engaged on a study of chemical test requirements for each kind of sewer pipe. At the meeting held February 21, at New York City, the membership of this sub-committee was increased by the addition of four non-producer members, thus making the membership consist of six non-producer and two producer members.

Sub-Committee III on Dimensions and their Permissible Variations—This sub-committee is engaged in the matters referred to in the last annual report. This sub-committee recommended certain changes for both clay and cement-concrete sewer pipe, which are being recommended by the committee.

Sub-Committee IV on Methods of Testing and Sub-Committee V on Nomenclature and Definitions are organized to continue studies connected with these subjects and to cooperate through their chairmen with Committees E-1 on Methods of Testing and Committee E-8 on Nomenclature and Definitions, respectively.

The meeting held in New York City on February 21 was attended and addressed by Mr. C. L. Warwick, Secretary-Treasurer of the Society, which resulted in the appointment of a sub-committee consisting of five members to aid in extending the Society membership.

It is recommended that the revisions of the Standard Specifications for Clay Sewer Pipe (C 13 – 20) accepted for publication as tentative in 1922[1] be adopted as standard and that the Standard Specifications be revised accordingly when the Book of Standards is next issued, in 1924.

It is recommended that the revisions of the Standard Specifications for Cement-Concrete Sewer Pipe (C 14 – 20) accepted for publication as tentative in 1922[1] be adopted as standard and that the Standard Specifications be revised accordingly when the Book of Standards is next issued, in 1924.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 22, Part I, p. 986 (1922).

It is recommended that the following revisions of the Standard Specifications for Clay Sewer Pipe (C 13 – 20)[2] be accepted for publication as tentative:

Table III.—In the second column, entitled "Laying Length," add the figures 2½ for sizes 27 in. to 42 in., inclusive.

It is recommended that the following revisions of the Standard Specifications for Cement-Concrete Sewer Pipe (C 14 – 20)[2] be accepted for publication as tentative:

Table III.—In the second column, entitled "Laying Length," add the figures 2½ for sizes 27 in. to 42 in., inclusive.

The above revisions are recommended since experience with the existing specifications has shown that the 2½-ft. length for the larger sizes of pipe should be included in the tables referred to.

It is recommended that the Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling (C 15 – 17 T) be continued as tentative for another year.

This report has been submitted to letter ballot of the committee, which consists of 26 members, of whom 19 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

RUDOLPH HERING,
Chairman.

A. J. PROVOST, JR.,
Vice-Chairman.

GEORGE T. HAMMOND,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Clay Sewer Pipe; and for Cement-Concrete Sewer Pipe, referred to in this report, were accepted for publication as tentative and appear on pages 963–964

A resolution on the death of Dr. Hering was presented by the committee and accepted for publication in the Proceedings. See page 31.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 22, Part I, p. 987 (1922).

[2] 1921 Book of A.S.T.M. Standards.

REPORT OF COMMITTEE C-6
ON
DRAIN TILE

The committee has held two meetings during the year in addition to the one held at Atlantic City during the last meeting of the Society. Both meetings were held in Chicago, one on January 19 and the other on April 6, 1923.

One of the two principal activities of the committee has been the continuation of the research investigation, begun in 1921, on the development of chemical tests and chemical test requirements for drain tile to determine their resistance to the action of alkalis and acids in the soil. Four separate investigations are being carried on by the following agencies: (1) Laboratory tests at the Iowa Engineering Experiment Station, under the immediate direction of Mr. W. J. Schlick, Drainage Engineer of the Experiment Station Staff; (2) field tests in South Dakota and Colorado and coordinate laboratory research, by the Structural Materials Research Laboratory of Lewis Institute, with the cooperation of the Portland Cement Association, under the direction of Mr. D. A. Abrams; (3) laboratory and field tests conducted by the Bureau of Public Roads, U. S. Department of Agriculture, in cooperation with the College of Agriculture, University of Minnesota, and the Department of Drainage and Waters, State of Minnesota; and (4) field and laboratory tests conducted by a committee of the Engineering Institute of Canada, and reported on by Mr. G. M. Williams, secretary of that committee.

Abstracts of the reports of these four investigations are given below:

I. IOWA ENGINEERING EXPERIMENT STATION

One of the principal objects of these investigations was the development of a test method for determining the durability of concrete drain tile in alkali soils. These investigations show that immersion in 15-per-cent solutions of sodium and magnesium sulfate may be used for such a test, but that the period of immersion would be too long to constitute a satisfactory test method except for use in determining the general quality of the output of a factory or a district.

The principal tests consist of a study of the effects of the chemical action on pieces of tile of 15 of the 21 series from the reserve stock of the tile prepared by the U. S. Bureau of Standards for their field investigations (started in 1912, and reported in *Technologic Papers Nos. 44 and 95*). The solutions used are

2, 5, 10, and 15-per-cent sodium sulfate, 10 and 15-per-cent magnesium sulfate, 10-per-cent sodium and magnesium chloride, and 15-per-cent sodium carbonate.

The results after periods of 78 to 104 weeks in the immersion tests and after 140 treatments in the combined test may be summarized as follows:

1. The results in these tests agree closely with those reported by the U. S. Bureau of Standards for the field investigations, the order of attack throughout the 15 series being practically the same in the two cases. These tests agree with the reports of other laboratory and field tests in showing that the action is most rapid with the sulfate solutions. In these tests, the action is most rapid also with the higher concentrations, and with magnesium salts in comparison with sodium salts.

2. The later results have emphasized the contrast in the action of the two sulfate solutions on specimens of certain series. The magnesium sulfate solution attacked the pieces from tile of Series 6 and 8 earlier and more rapidly than those from any other series, while the sodium sulfate solutions produced but slight effect on pieces from Series 6, and even less effect on those of Series 8. In the sodium solutions the pieces from Series 16 and 21 were attacked earlier and more rapidly than those of any other series, while the magnesium sulfate solutions produced more rapid action on several series than on these. The most rapid action in the combined test was on specimens of Series 2 and 15, the order of attack on other series being more similar to that in the magnesium sulfate solutions than that in the sodium sulfate solutions. Neither the physical nor the chemical data so far obtained afford any logical explanation for these variations.

3. The solutions of sodium chloride and sodium carbonate showed no visible effects after periods of 91 and 78 weeks, respectively. The specimens in the 10-per-cent solution of magnesium chloride showed no signs of action till 76 weeks, when one piece from Series 21 was so swollen and cracked as to be "destroyed" and another piece was "attacked." At 78 weeks this second piece was "destroyed" and a third piece "attacked."

4. The results from immersing pieces from the two absorption tests in 10-per-cent solutions of sodium sulfate showed the specimens from the standard boiling absorption test to be slightly more resistant than those from the 72-hour immersion tests. This is in contrast with the earlier work which showed that immersion of cured concrete specimens in boiling water caused a marked reduction in strength.

5. In nearly all cases the effect produced was very apparently due to a physical action which, in the case of the specimens continuously immersed in the solutions, must have been due to chemical action.

6. Chemical laboratory studies of the actions of the various salt solutions upon ground samples of cured neat cement gave results in close agreement with those summarized above. In these tests, treatment of 5-g. samples of the cured cement powder by 5-per-cent solutions of magnesium and sodium sulfate produced ultimate solid residues of materially greater weight (and presumably of materially greater volumes) than the original samples, and the difference was much greater for the magnesium than for the sodium sulfate. On the other hand, the treatment by the chloride solutions produced ultimate solid residues of slightly less weight (and presumably of slightly less volume) than the original samples.

These chemical studies were made simply to determine the possibilities and need for further work of this kind. The results were in such close agreement with other laboratory and field data, and seemed to offer such a logical and definite explanation of the actions taking place, that a more extended series of tests are now being made.

II. STRUCTURAL MATERIALS RESEARCH LABORATORY OF LEWIS INSTITUTE

The following is a summary of the results of the first and second inspections of concrete blocks exposed to alkali soil and water at Medicine Lake, S. D., and near Montrose, Colo.

The purpose of the tests was to determine the influence of various factors in the make-up of the concrete on its resistance to alkali action.

The field test specimens consisted of concrete blocks 10 in. in diameter and 24 in. long. The blocks were made at the laboratory and shipped to field sites, except those in Group 9 which were made at Montrose from local materials by the same man who made the blocks at the laboratory. At Medicine Lake, 628 specimens were placed in two rows parallel to the shore of the lake, where they were at all times in contact with water containing about 5 per cent of magnesium sulfate. At Montrose, 628 specimens made at the laboratory and 230 specimens made at Montrose of local materials were installed in an "alkali seep" which contained sodium sulfate up to a saturated solution. The blocks were placed on end in such a manner that they were imbedded $\frac{1}{3}$ to $\frac{1}{2}$ their length in alkali soil or water.

The following notes indicate the principal features of the results of the action of alkali on the specimens exposed. It should be pointed out that the conditions under which the specimens are exposed are much more severe than those encountered in practice. The conditions at Montrose are probably the most severe of any point on this continent. It is believed that the two locations chosen could not readily be improved on as to sites for *accelerated* tests. Frost action no doubt played a prominent part in the disintegration of the weaker concretes. During the winter extremely low temperatures occur at both sites.

1. *Effect of Quantity of Cement.*—The richer mixtures offered more resistance to alkali action than the leaner ones. The beneficial effect of additional cement was more apparent for the wet consistencies and finer aggregates.

2. *Effect of Quantity of Mixing Water.*—At Montrose an average of five mixtures, ranging from 1 : 5 to 1 : 1, showed only a slight difference in the resistance for consistencies ranging from dry to wet. For the leaner mixtures, however, considerably higher ratings were given the drier consistencies.

3. *Effect of Size and Grading of Aggregate.*—The relatively higher resistance of concrete made with the larger sizes of aggregate is clearly shown. For mixtures leaner than about 1 : 3, the specimens made with aggregates finer than 0 to $\frac{3}{8}$ in. were badly disintegrated. Little difference was found due to grading of aggregates.

4. *Effect of Type of Aggregate.*—The aggregates used in the concrete were limestone, granite, trap, slag, flint and sand and pebbles of limestone and siliceous origin. The different aggregates were proportioned in such a way as to give the same fineness modulus (5.50). None of the specimens showed any definite advantage of one aggregate over another.

5. *Effect of Kind of Cement.*—Specimens were made using four different brands of portland cement and two natural cements; mixtures of portland and natural cements were used in certain tests. Concrete mixtures ranging from 1 : 5 to 1 : 2 were made. No great differences were found among the four

portland cements. The natural cement mixtures offered very little resistance to the action of the alkali; practically all were disintegrated at the end of six or eight months.

6. *Effect of Powdered Admixtures.*—Powdered slag, raw mix for portland cement, kaolin, colloidal clay, and celite were used as admixtures in quantities up to 30 per cent of the cement for concrete mixtures of 1 : 5 to 1 : 2. The strength of concrete was reduced by all the admixtures except powdered slag, which showed a slight improvement; the greatest reductions occurred for the kaolin and colloidal clay.

7. *Effect of Integral Water- and Alkali-Proofing Compounds.*—Concrete was made for mixtures of 1 : 5 to 1 : 3, using different percentages of various compounds which have been recommended as integral water- and alkali-proofers. Almost without exception these materials were disappointing in that they gave poorer results than similar concrete without the compounds.

8. *Effect of Surface Coatings.*—In general, the surface coatings offered some protection to the concrete, although the tests were not advanced sufficiently to warrant definite conclusions as to the relative merits of the different types of coatings. Most of the coatings showed a progressive deterioration and many have been destroyed.

9. *Effect of Condition of Curing Concrete.*—The specimens which were cured for the longer periods have not been exposed to the alkali for a sufficient length of time to warrant making a comparison of different ages at this time.

10. A physical-chemical investigation into the reactions by which salts of the alkali and alkaline earth metals attack cement is being carried on in the laboratory under the direction of Mr. J. C. Witt. The object of this work is to study the mechanism by which alkali attacks proceed and to eliminate from serious consideration secondary or accompanying phenomena, which in the past have received unwarranted attention. The results of this investigation have not been released as yet.

III. U. S. BUREAU OF PUBLIC ROADS

In cooperation with the College of Agriculture, University of Minnesota, and the Department of Drainage and Waters, State of Minnesota, the Bureau of Public Roads, U. S. Department of Agriculture, is conducting investigations relative to drain tile at University Farm, St. Paul, Minn., under the direction of Mr. D. G. Miller, Senior Drainage Engineer.

When work at the laboratory was started, need was felt for some method whereby the progressive action of various solutions on experimental specimens could be expressed in measurable terms so that a comparative basis might be had. Heretofore, in work of this kind it has been customary to depend upon the general appearance of specimens supplemented by compression or tension tests of the pieces. Compression or tension tests of concrete are recognized as fundamental, but once a piece is tested its life is ended and for this reason there are limits to the adaptability of tests of this character. As the alkali problem in Minnesota early resolved itself into a sulfate problem, and as the action on concrete of the sulfates covering this area is accompanied by a very decided increase in volume, it was early decided to measure this action by the change in volume of the specimens as indicated by the change in lengths. The work to date indicates that any change in volume is accompanied by a loss of strength, and in general it may be said that an increase in length of 0.01 in. in a 2 by 4-in. cylinder means a loss in strength of about 50 per cent.

Studies are being made to determine the influence of the consistency, mix, and curing conditions upon specimens exposed to alkali solutions. The complete results of these experiments are not available, but they indicate that the consistency is the least important of the three variables mentioned. The amount of cement in the mix and the curing conditions are evidently of a far-reaching effect on the life of the specimens.

Experiments which it is hoped will show the influence of integral compounds, admixtures, and surface treatment in making concrete more resistant to alkali are in progress.

Numerous tests of tile have been made to determine the quality of tile in general use in the state, to determine how the concrete tile so tested compare with the specimens used in our experimental work in the laboratory, and to promote a general improvement in the quality of the drain tile used in the state.

In November, sixty different series of tile were made at a plant in Minnesota. These tile represent sixty different conditions of manufacture. The full results of these tests are not available, but when the data have been assembled and studied, it is planned to run other similar series in order to discover the most desirable combinations which can be manufactured on a commercial basis.

One fundamental difficulty of the present-day method of manufacturing the small-size concrete tile in the ordinary packer-head type machine is the dry mixture necessary in order that the jackets may be easily stripped. When consistency is above 75 per cent, jackets can not be stripped satisfactorily. Good results can be obtained with consistencies up to 65 per cent, and in some cases up to 70 per cent. Many of the plants manufacturing small sizes of tile ordinarily use a concrete of about 55 per cent consistency. For the large tile made in tamping machines, consistencies up to 90 per cent can be used, and compression tests of cubes cut from the walls of tile of this size show a compressive strength of 3000 to 3500 lb. per sq. in.

A survey of ground waters was extended north in the valley of the Red River of the North in Minnesota, and a small amount of work was done in North Dakota.

A number of tests of clay tile manufactured in the state have been made.

The Bureau of Public Roads has installed a number of sizes of concrete tile of known quality on a farm near Wilson, North Carolina, where concrete tile had previously failed. It is hoped to determine definitely whether or not good concrete tile will withstand the action of deleterious ingredients which are apparently present in this soil.

IV. ENGINEERING INSTITUTE OF CANADA

The committee after a study of the work of other investigators, as well as their own field tests and observations, agreed that the fact had been completely demonstrated that the best of concrete would be attacked under certain well-established conditions, and that little further field work should be commenced at the present time. The dissolving effect of sulfate salts on the constituents of portland cement made it clear that disintegration is primarily chemical, rather than mechanical, as has been assumed by many. Hence, the activities of the committee are at present directed mainly to chemical and petrographic studies of the reactions involved in the disintegration of concrete.

Since September, 1921, Mr. Thorvaldson, head of the chemistry department at the University of Saskatchewan, has been in charge of the chemical studies. The first chemical work on the problem was concerned with a study of the composition of the ground waters of the areas where failures of concrete foundations were general. This work is still being carried on in connection with the field investigations, especially with reference to seasonal variations, etc. The more important part of the chemical work deals with a study of the changes which take place in cement and concrete during disintegration by the action of sulfate solutions. In this work the problem is being attacked from two sides: First, by studying the action of various salts present in ground waters in the so-called alkali districts, on hydrated cement; and, second, by a separate study of the action of these solutions on all the substances present in cement systems, or disintegrated cements. This includes the preparation, in pure state, of all substances which may be present in such systems and a study of their solubilities in, and reactions with, the various salt solutions.

No results of these chemical studies are given at this time. It is planned to continue this work through the next two years if necessary.

Another activity of Committee C-6 has had for its object the standardization of drain-tile sizes. In April, 1922, a sub-committee, including in its personnel representatives of the American Concrete Pipe Association, the Clay Products Association, and the U. S. Bureau of Public Roads, was appointed to investigate this subject. The work of the sub-committee was tied in, at least informally, with the work of the Division of Simplified Practice of the U. S. Department of Commerce. An abstract of the report of the sub-committee which was presented to the committee on January 19, 1923, and approved, is as follows:

The main lines of investigation were (1) what sizes of tile are really needed by engineers in the design of drainage systems, and (2) what effect the elimination of certain sizes of tile now kept in stock by the manufacturers would have on the prices of those sizes retained as standard.

To assist in answering the first of these questions, a questionnaire was sent to 250 representative drainage engineers, 64 of whom responded. The replies to the questionnaire indicate clearly that certain odd sizes now manufactured are not considered necessary by the large majority of engineers.

At the suggestion of Mr. P. G. Agnew, Secretary of the American Engineering Standards Committee, the System of Preferred Numbers which has been used to a large extent in Germany in determining the sizes of various industrial products was given careful consideration in connection with the standardization of drain-tile sizes. This system consists in selecting a series of numbers or sizes so that each will bear a constant ratio to the preceding one. In other words, the numbers or sizes constitute a geometrical series. The ratios which have been adopted in Germany are the fifth, tenth, twentieth, fortieth, and eightieth roots of 10. Each series consists of eleven sizes, numbered from 0 to 10. The No. 10 size is ten times the No. 0 size, and the ratio between sizes is some root of 10. The tenth-root series seems best adapted to drain-tile sizes. Starting with the 6-in. size as No. 0 of the tenth-root series, we get the following sizes: 6.00, 7.55, 9.51, 11.97, 15.07, 18.97, 23.89, 30.07, 37.86, 47.66

and 60.00 in. By extending this series below the 6-in. size, using the same ratio, we get 4.77, and 3.79 in. The commercial sizes most nearly approximating these values are 4, 5, 6, 8, 10, 12, 15, 19, 24, 30, 38, 48, and 60 in.

The committee had no difficulty in agreeing that 4, 5, 6, 8, 10, and 12-in. tile are necessary in drainage work. Above the 12-in. size the opinions of engineers vary widely. After careful study, it was decided that between 12 and 24 in. there should be a constant ratio between the capacity of any tile and that of the next larger size. In determining this ratio the uncertain factors used in designing drainage systems were studied. These are two in number: (1) the roughness factor and (2) the drainage coefficient.

A report of the Committee on Drainage of the American Society of Agricultural Engineers shows that values of the roughness factor used by engineers in different parts of the country range from 0.011 to 0.017, with 0.013 and 0.015 as the more common values. The experiments made by the Bureau of Public Roads and reported in *Bulletin No. 854*, entitled "Flow of Water in Drain Tile," by D. L. Yarnell, gave values of the roughness factor from 0.010 to 0.012. The recommendation made by Mr. Yarnell for average conditions was 0.012. A difference of 0.001 in the value of this factor makes a difference of about ten per cent in the computed discharge. Therefore, the committee believes that the uncertainty in the computed discharge of a tile line, due to the chosen roughness factor, might easily amount to ten per cent.

There have been few field investigations made on the drainage coefficient. Data obtained by the American Society of Agricultural Engineers show that values from ⅛ to 1 in. in 24 hours are used in different parts of the country, and in the same state variations of ¼ in. are common. The factors which determine the amount of sub-surface runoff are the intensity and duration of precipitation, the character of the soil, the topography, and the depth and spacing of drains. The climatic, geologic, and topographic factors are so variable that it is impossible to choose a drainage coefficient with any certainty. The use of ¼ in. rather than ⅛ n. means an increase in the discharge of 100 per cent; that of ⅜ in. rather than ¼ in., an increase of 50 per cent; and ½ in. rather than ⅜ in. an increase of 33⅓ per cent. With these facts in mind, it is believed that the difference between the computed discharge and the actual discharge might easily amount to as much as the difference in the capacities of successive sizes of drain tile as proposed.

The sizes of drain tile recommended as standard are 4, 5, 6, 8, 10, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 54, and 60 in. These sizes up to the 24-in. size follow very closely the tenth-root series of preferred numbers. For sizes above 24 in., an increment of 3 in. is recommended, deviating from the preferred number system, for the reason that the larger tile are used as outlets and that the sizes of such outlets are usually special and their capacities can be more accurately determined from the capacities of the tributary laterals.

As to the second line of investigation, the sub-committee was unable to ascertain the amount of saving by the elimination of certain sizes, because during the period of transition it will be necessary for the manufacturer to carry stocks of both the old sizes and the new ones; but it is believed that ultimately the saving to the land owner will be sufficient to warrant the proposed change.

Although the sizes of tile recommended by the sub-committee were approved by Committee C-6, it was decided that the sizes above

42 in. should be omitted for the present from Table I of the Specifications C 4, because of the lack of data as to the strength requirements of the larger sizes.

Committee C-6 recommends the following changes in the Standard Specifications for Drain Tile (C 4 – 21):[1]

Section 15.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "The purchaser shall choose (1) sand bearings, (2) [hydraulic] *two-edge* bearings, or (3) [three-point] *three-edge* bearings for use in making strength tests of drain tile. (See Sections 18, 19, and 20.)"

Section 16.—Change the second paragraph to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "The ordinary supporting strength shall be calculated by multiplying the test breaking loads by the following factors: For sand bearings, 1.00; for [hydraulic] *two-edge* bearings, [1.25] *1.50*; for [three-point] *three-edge* bearings, 1.50."

Section 17.—Change the first sentence of the second paragraph to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "Five-eighths of the weight of the tile per linear foot for sand bearings, or three-fourths for [hydraulic or three-point] *two-edge or three-edge* bearings, shall be added to W in computing the maximum bending moment M, when such addition exceeds 5 per cent of W."

Section 19.—Change from its present form: namely,

> "19. (See Fig. 2.)—When hydraulic bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.
>
> "An hydraulic bearing shall be composed of a wooden platen, to which is attached, as hereinafter described, a section of rubber hose. The hose shall lie against the tile, and the pressure shall be applied to the hose through the platen.
>
> "The platen shall be built of strong wood, and shall be not less than 6 by 6 in. in section, and its least length shall be the length of the tile plus 8 in. One-inch quarter rounds, with their convex surfaces facing and 2 in. apart in the clear, shall be firmly attached to the bearing side. The straight portion of this face shall extend at least the length of the tile, and the platen beyond this length may be cut to the arc of a circle.
>
> "Between the quarter rounds shall be laid a piece of 2½-in. hose which shall be closed in a water-tight manner at each end by clamps. The hose shall contain a volume of water not less than one-half nor more than two-thirds

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[1] 1921 Book of A.S.T.M. Standards.

its capacity, when completely distended. This hose may be attached to the platen at either end in any satisfactory manner which will not induce wrinkling when under test pressure.

"The test load shall be applied at the middle of the top bearing, in such a way as to leave the bearing free to move in the vertical plane of the axis of the tile.

"It is recommended that stops be screwed to the platen, symmetrical with the point of application of the load, and at a distance apart not greater than the length of the tile plus ½ in. This will help center the load coming upon the tile."

to read as follows:

"*Two-edge Bearings.* (See Fig. 2.)—When two-edge bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.

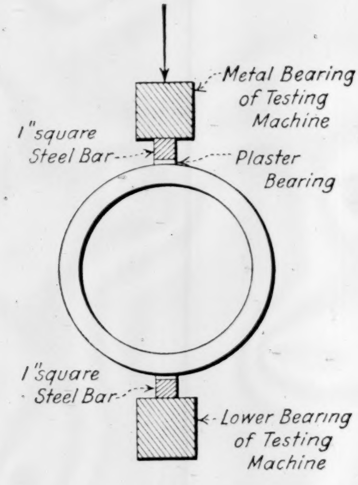
Metal Bearing of Testing Machine
1" square Steel Bar
Plaster Bearing
1" square Steel Bar
Lower Bearing of Testing Machine

FIG. 1.—Two-Edge Bearings.

"The tile to be tested shall be supported by a metallic knife bearing 1 in. wide and extending the length of the tile. Before the tile is placed, a fillet of plaster of Paris and sand 1 in. wide, and thick enough to compensate for all the inequalities of the tile barrel, shall be cast on the surface of the knife-edge bearing. The tile shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The load shall be applied through an upper knife bearing of the same size and length as the lower bearing. A plaster-of-Paris fillet 1 in. wide shall be cast along the length of the crown of the tile to equalize the lower bearing before the upper one is brought into contact.

"Both of the bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the test without lost motion, vibration, or sudden shock."

Section 20.—Change the first sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "*Three-edge Bearings.* (See Fig. 3.)—When [three-point] *three-edge* bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test."

Table I.—Change Table I to appear as follows:

TABLE I.—PHYSICAL TEST REQUIREMENTS FOR DIFFERENT CLASSES OF DRAIN TILE

Internal Diameter of Tile, in.	Farm Drain Tile				Standard Drain Tile				Extra-Quality Drain Tile			
	Minimum Average Ordinary Supporting Strength, lb. per linear ft.	Maximum Average Absorption by Standard Boiling Test, per cent			Minimum Average Ordinary Supporting Strength, lb. per linear ft.	Maximum Average Absorption by Standard Boiling Test, per cent			Minimum Average Ordinary Supporting Strength, lb. per linear ft.	Maximum Average Absorption by Standard Boiling Test, per cent		
		Shale and Fire-Clay Tile	Surface-Clay Tile	Concrete Tile		Shale and Fire-Clay Tile	Surface-Clay Tile	Concrete Tile		Shale and Fire-Clay Tile	Surface-Clay Tile	Concrete Tile
4	800	11	14	12	1200	9	13	10	1600	7	11	9
5	800	11	14	12	1200	9	13	10	1600	7	11	9
6	800	11	14	12	1200	9	13	10	1600	7	11	9
8	800	11	14	12	1200	9	13	10	1600	7	11	9
10	800	11	14	12	1200	9	13	10	1600	7	11	9
12	800	11	14	12	1200	9	13	10	1600	7	11	9
15	1000	11	14	12	1300	9	13	10	1600	7	11	9
18	(Not Permitted)	(Not Permitted)	(Not Permitted)	(Not Permitted)	1400	9	13	10	1800	7	11	9
21					1550	9	13	10	2100	7	11	9
24					1700	9	13	10	2400	7	11	9
27					1850	9	13	10	2700	7	11	9
30					2000	9	13	10	3000	7	11	9
33					2150	9	13	10	3300	7	11	9
36					2300	9	13	10	3600	7	11	9
39					2450	9	13	10	3900	7	11	9
42					2600	9	13	10	4200	7	11	9

Fig. 2.—Change Fig. 2 to conform to Fig. 1 above.

Fig. 3.—Change the title of Fig. 3 from "Three-Point Bearings" to read "Three-Edge Bearings."

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 11 have voted affirmatively, 2 negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

ANSON MARSTON,
Chairman.

G. W. PICKELS,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Drain Tile, referred to in this report, were accepted for publication as tentative and appear on page 960.

REPORT OF COMMITTEE C-7

ON

LIME

Committee C-7 has held three regular meetings since the last report was presented, including a short session at Atlantic City at the time of the last annual meeting. At the November meeting, held in Philadelphia, especial attention was given to the uses of lime in water purification. In addition to the meeting of the sub-committee on chemical uses of lime, at which the time was devoted to this question, a joint meeting was held with the Philadelphia Section of the American Chemical Society. At this joint meeting Mr. W. D. Collins, of the U. S. Geological Survey, gave a lecture on "Hardness of Large Public Water Supplies in the United States." It was discussed by Mr. Thaddeus Merriman, Chief Engineer, New York City Board of Water Supply, Mr. C. R. Knowles, Superintendent, Water Service, Illinois Central Railroad, Mr. Bartlett, of the American Water Softening Co., Mr. R. C. Bardwell, Engineer, Water Service, Missouri Pacific Railroad, and Mr. Lyle L. Jenne, of the Philadelphia Bureau of Water. There were also present representatives of the American Railway Engineering Association, their attendance having been sought with a view to drawing up uniform specifications for lime for water softening.

At the April meeting, held in the offices of the National Lime Association, Washington, D. C., arrangements were completed for cooperation in the work of the Sub-Committee on Chemical Lime with a committee of the Interdepartmental Conference, to produce, if possible, uniform specifications.

The various activities of the committee are grouped for convenience in the order of the respective sub-committees:

Sub-Committee II on Structural Lime.—The plaster panels mentioned in the 1922 report of the committee have given some definite results in the first year and are being held for further examination. They are also being used as a check for present methods of testing for soundness. The committee has developed a new method for testing consistency, which is presented as a revision of the Tentative Specifications for Hydrated Lime for Structural Purposes (C 6 – 22 T).[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 691 (1922).

The several revisions recommended in these specifications are as follows:

Section 13.—Omit the present Section 13, reading as follows:

"In a suitable vessel, 200 g. of the sample shall be mixed with 600 g. of standard Ottawa sand. Sufficient water shall be added to bring the mixture to the proper consistency which shall be determined as follows:

"A clean and well-oiled cylindrical mold, 5 cm. (2 in.) in diameter by 10 cm. (4 in.) high, shall be prepared and mounted on a glass plate. This mold shall be filled with the lime mortar, struck off level and the mold removed immediately by raising it vertically. The mortar is of the proper consistency when the final height of the cylinder, after the mold is removed, is 9 cm. (3½ in.).

"The mixture having been brought to the proper consistency, it shall be molded to form six briquettes. These briquettes shall be of the form and size specified in Section 50 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials. After the molds have been filled with the mortar, the whole shall be placed on edge in a damp closet and permitted to stand over night. They shall then be removed from the damp closet and permitted to stand exposed to room atmosphere for 24 hours longer. The briquettes shall then be removed from the molds and shall be stored on edge in room atmosphere in such a way that the air can circulate freely around each briquette until ready for test.

"For measuring the tensile strength of lime mortars the machine used shall be direct acting; that is, there shall be no levers introduced between the load and the specimen. The cut-off mechanism which stops the application of load shall be automatic and instantaneous. The machine shall be regulated to apply the load at the rate of 15 lb. per minute. The maximum capacity of the machine shall be not less than 50 nor more than 100 lb., and it shall be sensitive to within 1 per cent at any load."

Add a new Section 13 to read as follows:

"13. *Consistency.*—Consistency of lime putty shall be determined by the use of a modified form of the Vicat apparatus, a plunger 12.5 mm. in diameter and weighing 30 g., being substituted for the usual 300-g. plunger. This plunger is conveniently made of 12.5-mm. aluminum tubing with square closed end.

"The lime shall be made to a stiff putty by mixing with water and the putty soaked over night in a suitable container adapted to prevent the evaporation of moisture. The soaked putty shall be placed in the rubber ring used with the Vicat apparatus, with the rubber ring resting on a glass plate.

"The initial reading shall be taken with the bottom of the plunger set in contact with the surface of the sample. The plunger shall then be released and the final reading taken after 30 seconds. The consistency of the putty is "standard" when the plunger penetrates 20 mm. into the mass.

"If the plunger does not penetrate 20 mm., the putty shall be removed from the mold and mixed with a little more water until a penetration of 20 mm. is obtained.

"If the plunger penetrates more than 20 mm., additions of lime shall not be made, but the material shall be discarded and a new mixture prepared. In preparing the lime for soaking, 'snap' tests should be made to avoid obtaining too thin a putty.

"For measuring consistency of lime mortar, the same plunger shall be loaded to weigh 100 g. The same procedure shall be followed as detailed above, and the consistency of the mortar is "standard" when the plunger penetrates 20 mm. into the mass."

Add a new Section 14 to read as follows, re-numbering the subsequent sections accordingly:

"14. *Tensile Strength.*—In a suitable vessel, 200 g. of the sample shall be mixed with 600 g. of standard Ottawa sand. Sufficient water shall be added to bring the mixture to standard consistency as defined above with a permissible variation of ±5 mm.

"The mixture having been brought to the proper consistency, it shall be molded to form six briquettes. These briquettes shall be of the form and size specified in Section 50 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials. After the molds have been filled with mortar, the whole shall be placed on edge in a damp closet and allowed to stand over night. They shall then be removed from the damp closet and be exposed to room atmosphere for 24 hours longer. The briquettes shall then be removed from the molds and shall be stored on edge in room atmosphere in such a way that the air can circulate freely around each briquette until ready for test.

"For measuring the tensile strength of lime mortars, the machine used shall be direct acting, that is, there shall be no levers introduced between the load and the specimen. The cut-off mechanism which stops the application of load shall be automatic and instantaneous. The machine shall be regulated to apply the load at the rate of 15 lb. per minute. The maximum capacity of the machine shall be not less than 50 nor more than 100 lb., and it shall be sensitive to within 1 per cent at any load."

Change Section 15 from its present form: namely,

"15. The plasticity shall be determined by means of the apparatus shown in Fig. 1 as follows:

"Three hundred grams of the sample shall be mixed with enough water to form a thick paste. This shall be covered with a damp cloth and permitted to stand for not less than 16 nor more than 24 hours.

"NOTE.—It is necessary that the paste be thick enough so that it can be diluted to 'normal consistency' by the addition of more water, after standing. The proportion of water will vary with different limes, so that no definite amount can be recommended.

"The mold[1] shall be placed on a glass plate and filled with the paste and struck off level. The mold shall be removed immediately by raising it vertically. The final height of the paste shall be measured. More water shall be added if necessary and the test repeated until the final height of the paste is found to be 1¼ in. ±$\frac{1}{16}$ in. (31 mm. ±1.5 mm.).

"The mold shall be placed on a porcelain base plate and filled with the paste, and struck off level. The mold shall be removed by raising it vertically, without distorting the paste. The base plate and paste shall be placed in the instrument (Fig. 1) and the carriage turned up by hand until the surface of the paste comes in contact with the disk.

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[1] This mold is the same as that specified in Section 38 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials, 1921 Book of A.S.T.M. Standards.

"The carriage shall be thrown into gear and the motor started. It is essential that the motor shall be started exactly sixty seconds after the first portion of paste has been put in the mold. The time when the first portion of paste is put in the mold shall be recorded as zero time—the motor therefore is started at one minute.

"The scale reading shall be taken and recorded every minute until the test is complete.

"The test shall be considered complete when (*a*) the force equals 100 as shown on the scale; (*b*) any reading is less than the one before, indicating that the bob has fallen back; or (*c*) the bob has remained stationary for two consecutive readings (one minute) and the specimen has either visibly ruptured or broken loose from the base plate.

"The time and the scale reading at the end of the experiment shall be noted. The time, in minutes, elapsed since zero time shall be called T and the scale reading (indicating the force) F.

"The plasticity figure, P, shall be calculated from the formula:

$$P = \sqrt{F^2 + (10\ T)^2}.\text{"}$$

to read as follows:

"The plasticity shall be determined by means of the apparatus shown in Fig. 1 as follows: Three hundred grams of the sample shall be mixed with enough water to form a thick putty. After aging for not less than 16 nor more than 24 hours, this putty shall be adjusted to standard consistency, as defined in Section 13, with a permissible variation of ±5 mm.

"The mold[1] shall be placed on a porcelain base plate and filled with the paste, and struck off level. The mold shall be removed by raising it vertically without distorting the paste. The base plate and paste shall be placed in the instrument (Fig. 1) and the carriage turned up by hand until the surface of the paste comes in contact with the disk and there is some torsion set up as indicated by a slight movement of the dial.

"The carriage shall be thrown into gear and the motor started. It is essential that the motor shall be started exactly sixty seconds after the first portion of paste has been put in the mold. The time when the first portion of paste is put in the mold shall be recorded as zero time—the motor therefore is started at one minute.

"Care shall be taken to protect the specimen from drafts, throughout the test.

"The scale reading shall be observed and recorded every minute until the test is complete.

"The test shall be considered complete when (*a*) the force equals 100 as shown on the scale; (*b*) any reading is less than the one before; or (*c*) the scale reading has remained constant for two consecutive observations (one minute) and the specimen has either visibly ruptured or broken loose from the base plate.

---

[1] This mold is the same as that specified in Section 38 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials, 1921 Book of A.S.T.M. Standards.

"The time and the scale reading at the end of the experiment shall be noted. The time, in minutes, elapsed since zero time shall be called T and the scale reading (indicating the force) F.

"The plasticity figure, P, shall be calculated from the formula:

$$P = \sqrt{F^2 + (10\ T)^2}."$$

Committee C-7 recommends that the specifications be revised as indicated and that the specifications as revised be continued as tentative.

Sub-Committee III on Lime for Chemical Industries.—Two meetings have been held by the cooperating committee of Sub-Committee III and the Interdepartmental Conference. Work is being carried on toward developing specifications for water purification, glass manufacture, leather manufacture and causticization.

Sub-Committee IV on Agricultural Lime.—This sub-committee is continuing its studies of solubility of liming materials, and undertaking a study of the uses of lime in crop protection work.

Sub-Committee V on Methods of Analysis.—This sub-committee offers the following revisions of the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (C 50 - 22 T):[1]

Section 6.—The statement now appears that this section, covering the treatment of the sample at the laboratory, is to be supplied by the committee. The material of this section is now presented to read as follows:

> "*Sample for Chemical Analysis.*—The sample as received at the laboratory shall be thoroughly mixed, and reduced in quantity by the usual methods of quartering, to give a minimum portion of 75 g. This portion shall be ground, either by suitable mechanical device, or by hand in an agate mortar, until it all passes a No. 100 sieve. It shall then be thoroughly mixed and placed in an air-tight container for use in the determination of the chemical composition."

Add a new Section 7 to read as follows, re-numbering the subsequent sections accordingly:

> "*Samples for Special Tests.*—Samples to be used for such special tests as may be required by individual specifications shall be obtained by mixing and quartering the material remaining after removal of the 75-g. portion for chemical analysis. The quantity of sample and the screen size of the particles will depend upon the requirements of the individual specifications."

Committee C-7 recommends that the methods be revised as indicated and that the methods as revised be continued as tentative.

Sub-Committee VI on Plasticity is continuing the work of calibrating plasticimeters. Further experiments have been made to verify the directions for the use of the machine. Investigations are under way to find the relation between plasticity of a lime-sand mortar and sand-carrying capacity of a lime.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 728 (1922).

Sub-Committee VII on Highway Lime reports progress on the use of hydrated lime in highway construction, both as an admixture in portland cement concrete and as a treatment of sub-grade soils to reduce volumetric change and to increase bearing power.

Committee C-7 recommends that the following tentative standards be continued as tentative without revision:

For Quicklime for Structural Purposes (C 5 – 22 T);

For Quicklime and Hydrated Lime for Use in the Cooking of Rags for the Manufacture of Paper (C 45 – 22 T);

For Quicklime and Hydrated Lime for Use in the Manufacture of Sulfite Pulp (C 46 – 22 T);

For Hydrated Lime for the Manufacture of Varnish (C 47 – 22 T);

For Quicklime and Hydrated Lime for Use in the Textile Industry (C 48 – 22 T);

For Quicklime and Hydrated Lime for the Manufacture of Silica Brick (C 49 – 22 T).

Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 – 22 T).

Tentative Definitions of Terms Relating to Lime (C 51 – 22 T).

This report has been submitted to letter ballot of the committee, which consists of 42 members, of whom 29 have voted affirmatively, none negatively, and 13 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. C. BERRY,
Chairman.

G. W. HUTCHINSON,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Specifications for Hydrated Lime for Structural Purposes; and of the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products, referred to in this report, were accepted. The tentative standards as thus revised appear on pages 620 and 636, respectively.

REPORT OF COMMITTEE C-8
ON
REFRACTORIES

Committee C-8 has no new standards or methods to offer this year as a result of its work but it offers instead a progress report of its reorganization.

For nine years, the work of Committee C-8 has proceeded along conventional lines. A number of standard methods of tests were prepared and accepted by the Society but for the last four or five years the committee has been seriously hampered in its work because of the question of specifications. Apparently it should not be difficult, with the background of standard methods of testing, to evolve acceptable specifications, but Committee C-8 became so divided in the discussion of this subject that for several years it made but little progress. The division of opinion as we see it now was an absolutely normal one, due to the existing commercial practices. When it became evident that further progress with our existing organization was apparently impossible, the committee did not give up in despair, but it decided for one year to stop the ordinary routine consideration of its work and a special committee was appointed to study Committee C-8, the refractory industry, and the committee's duty to the Society.

This special committee was made up of an equal number of producers and consumers, and for some nine months it worked strenuously on this problem. The report of this committee has just been presented to and accepted by Committee C-8 and this report furnishes the basis of the report of Committee C-8 for its year's work.

The committee's report was devoted to three general questions:

1. The organization of Committee C-8;
2. The policy of Committee C-8; and
3. A study of the industrial requirements for refractories as the basis for their classification and, therefore, their specifications.

ORGANIZATION

The whole organization of Committee C-8 has been considerably changed by the adoption of a new set of by-laws and with this new organization the active direction of the committee has been put into the hands of an Advisory Committee, and the work has been put into the hands of four sub-committees:

1. Sub-Committee on Tests and Specifications.
2. Sub-Committee on Research.
3. Sub-Committee on Nomenclature.
4. Sub-Committee on Industrial Survey.

The Sub-Committee on Tests and Specifications will have sections on all of the different tests which will form a part of our proposed specifications. These will be temperature, load, abrasion, slagging, and spalling, and in addition there will be a section on precision and tolerances.

The Sub-Committee on Research will handle all of those tests which are not immediately applicable to specifications.

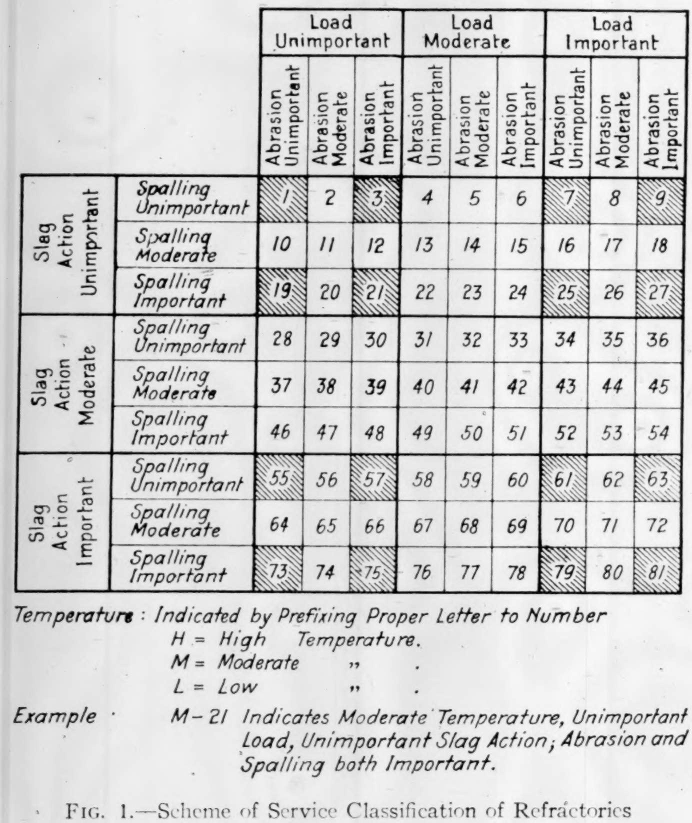
The Sub-Committee on Nomenclature requires no elaboration.

The Sub-Committee on Industrial Survey is intended to keep Committee C-8 in intimate touch with the actual requirements of the industry. This sub-committee is charged with the duty of investigating all of the uses for refractories and of determining the limits required and of presenting them in such a form that the Sub-Committee on Tests and Specifications will have the information necessary to its work.

CLASSIFICATION OF REFRACTORIES

It was early realized by the special committee that there was apparently no hope of reconciling the divergent views of Committee C-8 regarding specifications if the present trade practices were to be followed. These have to do particularly with the grading of refractories into first, second and third quality. It was necessary that some scheme of classification of the requirements of the industry should be evolved that would avoid this method of expression. The special committee adopted as a fundamental in its discussion of the proposition that the consumer desires and purchases not bricks but service and accordingly made service the key-note of its work. With this decision as a basis, it carefully investigated a number of suggested forms of classification. Many of these were very concise but were open to the objection that certain properties of the refractory materials were necessarily assumed to be independent. While it was the opinion of several of the members of the committee that in the present state of the art this was true, yet it was felt beyond the province of Committee C-8 to say that this was necessarily so and that it was impossible, for instance, to have a refractory that would withstand very high abrasion and which at the same time would have a high spalling test.

After some six months' deliberation, the committee decided to abandon the idea of a concise classification and to adopt a comprehensive classification that in its opinion would cover all of the refractory requirements without any limitation. This scheme of classification is shown in Fig. 1 and is based on resistance to temperature, load, abrasion, slagging and spalling, and assumes that there may be required three degrees of resistance to each of these qualities; these are defined as unimportant, moderate and important.



		Load Unimportant			Load Moderate			Load Important		
		Abrasion Unimportant	Abrasion Moderate	Abrasion Important	Abrasion Unimportant	Abrasion Moderate	Abrasion Important	Abrasion Unimportant	Abrasion Moderate	Abrasion Important
Slag Action Unimportant	Spalling Unimportant	1	2	3	4	5	6	7	8	9
	Spalling Moderate	10	11	12	13	14	15	16	17	18
	Spalling Important	19	20	21	22	23	24	25	26	27
Slag Action Moderate	Spalling Unimportant	28	29	30	31	32	33	34	35	36
	Spalling Moderate	37	38	39	40	41	42	43	44	45
	Spalling Important	46	47	48	49	50	51	52	53	54
Slag Action Important	Spalling Unimportant	55	56	57	58	59	60	61	62	63
	Spalling Moderate	64	65	66	67	68	69	70	71	72
	Spalling Important	73	74	75	76	77	78	79	80	81

Temperature : *Indicated by Prefixing Proper Letter to Number*
H = High Temperature.
M = Moderate "
L = Low "

Example *M-21 Indicates Moderate Temperature, Unimportant Load, Unimportant Slag Action; Abrasion and Spalling both Important.*

FIG. 1.—Scheme of Service Classification of Refractories

This scheme of classification will give 81 possible types of service and it is believed that it is sufficiently comprehensive to cover our present requirements and to be free from any question of dependent qualities.

In studying the comprehensive scheme, the committee was struck by the fact that they had but a very meagre knowledge of a practical application for many of these types or classification of service and it was believed that it would be better in the beginning to work on a more simple form of classification but so chosen that it would be capable of expansion should an occasion arise. The committee believes it has accomplished this simplification by using the comprehensive scheme as a foundation and then choosing four classes at each corner of the main structure. The classes thus chosen are shown cross-hatched in Fig. 1. This is practically equivalent to omitting one degree of resistance (the moderate degree) to each of the qualities. This simplified scheme of 16 classes of service is believed to be ample for our present use and yet the classes are so chosen that should the demand arise in the future, it can be readily extended without destroying any of the work that has already been done on it. Moreover, the simplified classification will bring the more necessary work of specifications to within a more reasonable compass in view of our present knowledge of furnace conditions and requirements.

TABLE I.—SUMMARY OF TESTS REQUIRED

Class	Temperature	Abrasion	Load	Spalling	Slag
1 H, M, or L	Yes	...	...	...	...
3 H, M, or L	Yes	Yes	...	...	...
7 H, M, or L	Yes	...	Yes	...	...
9 H, M, or L	Yes	Yes	Yes	...	...
19 H, M, or L	Yes	...	...	Yes	...
21 H, M, or L	Yes	Yes	...	Yes	...
25 H, M, or L	Yes	...	Yes	Yes	...
27 H, M, or L	Yes	Yes	Yes	Yes	...
55 H, M, or L	Yes	...	...	...	Yes
57 H, M, or L	Yes	Yes	...	...	Yes
61 H, M, or L	Yes	...	Yes	...	Yes
63 H, M, or L	Yes	Yes	Yes	...	Yes
73 H, M, or L	Yes	...	...	Yes	Yes
75 H, M, or L	Yes	Yes	...	Yes	Yes
79 H, M, or L	Yes	...	Yes	Yes	Yes
81 H, M, or L	Yes	Yes	Yes	Yes	Yes

The committee wishes to point out again that such a scheme of classification of service entirely eliminates any reference to grade of brick which was the principal stumbling block in our former work. The specifications would then be drawn to cover these requirements. In the use of this scheme, the work of the industrial survey committee will indicate that for a certain type of furnace the service requirements are in accordance with, let us say, class 57. One very important factor in connection with the adoption of such a scheme of service classification is the fact that it shows immediately what tests are required for any type of service. These test requirements are summarized in Table I.

POLICY OF COMMITTEE C-8

The special committee has given a great deal of thought to the matter of formulating a definite policy for the work of Committee C-8 and as a result of its work, makes the following proposal:

In order that Committee C-8 should function most efficiently, so that it may be of the greatest service to both the producers and users of refractories, it is felt that the present plan of organization should be revised and that a new form of organization should be set up in which the chairman should be relieved of the responsibility and detailed work of the sub-committees and that this responsibility should be vested in a co-ordinating committee which in the by-laws which have been drawn up is called an Advisory Committee composed equally of producers and consumers.

With this new form of organization, the work of the committee should proceed along the following lines:

1. The formulation of a service classification of refractories. This has been undertaken by the special committee and is made a part of this report.

2. An industrial survey of furnaces and furnace conditions in accordance with this service classification. This work is to be taken up by the Sub-Committee on Industrial Survey.

3. The definition; interpretation and further development of tests. A proposed Sub-Committee on Tests and Specifications will undertake this work.

4. The preparation of specifications. This work will be done by a Sub-Committee on Tests and Specifications in cooperation with the Sub-Committee on Industrial Survey, both working together under the Advisory Committee.

In the matter of drawing specifications, it is proposed that it shall be the policy of Committee C-8 to draw specifications only for general classes of refractories for which there is a commercial demand and not to draw specifications for special isolated requirements.

In order that the work of the Sub-Committee on Tests and Specifications through its section may go forward with maximum efficiency and coordination, it is recommended that each section should adopt the same method of attack.

(*a*) That the first step should be the preparation of clear cut definitions of the property that the section is studying.

(*b*) That a careful study should be made of the various tests with a view to developing limitations and the proper interpretations of their results.

(*c*) That special attention should be given to the adaptation of each test to its use in specifications and that further developments should be immediately studied. Many of our present tests are not adapted in their present form to application in commercial specifications.

Committee C-8 feels that the year past has not been wasted but that it has made a very distinctive advance in its work and that the time given over to study of itself and of the industry that it represents has been well repaid.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

REPORT OF COMMITTEE C-9
ON
CONCRETE AND CONCRETE AGGREGATES

The activity of Committee C-9 during the past year has not been so great as in some previous years, which may, perhaps, be explained by the fact that the easier and simpler problems have gradually been disposed of, leaving a preponderance of those which are more controversial and less amenable to the ordinary methods of procedure. Thus, comparatively little progress has been made on the theory of proportioning and the design of concrete mixtures, and also on the improvement of the tentative specifications for concrete aggregates. Both of these subjects have received much discussion, but the former involves an extensive analytical study of existing data for which time has not been available to the sub-committee in charge of the work, and the latter has developed only slowly in the face of strong differences of opinion, which cannot be reconciled until more definite and conclusive data are available.

A brief review of the status of recently adopted standards and of existing tentative standards for which the committee is responsible will serve to show how the work of the committee now stands. During the past several years the following standards originating with Committee C-9 have been adopted by the Society:

Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29 - 21).
Standard Method of Test for Voids in Fine Aggregate for Concrete (C 30 - 22).
Standard Method of Test for Organic Impurities in Sands for Concrete (C 40 - 22).
Standard Method of Making and Storing Specimens of Concrete in the Field (C 31 - 21).
Standard Method of Test for Sieve Analysis of Aggregates for Concrete (C 41 - 22).

The first three standards were adopted by the American Engineering Standards Committee May 29, 1923, as Tentative American Standards.

In addition to the above standards the following tentative standards have been developed:

Tentative Method of Securing Specimens of Hardened Concrete from the Structure (C 42 - 21 T).

Tentative Methods of Making Compression Tests of Concrete (C 39 – 21 T).

Tentative Specifications for Concrete Aggregates (C 33 – 21 T).

In regard to the Tentative Specifications for Concrete Aggregates (C 33 – 21 T)[1] the committee feels warranted in introducing certain changes which are sufficiently important to be submitted herewith as revised tentative standards appended hereto.[2] It is not to be inferred, however, that the committee is satisfied with the specifications for fine aggregates as given in the revised standard. Attention is being focussed sharply upon the questions at issue and there is good reason to believe that these tentative specifications will again be revised in more nearly final form next year.

In regard to the changes which have been made in the paragraphs dealing with coarse aggregates, the recognition of air-cooled blast-furnace slag is the most important. A large amount of test data has shown this material to be acceptable as concrete aggregate, and there is also a large amount of data from the field in testimony of the durability and permanency of slag concrete structures. The only special restriction which has been put upon this material is a limitation upon weight per cubic foot, the specified weights being high enough, it is believed, to exclude undesirable material. No restriction has been placed upon the sulfur content of slag, for the reason that inspections made by members of the committee of reinforced slag concrete structures in the course of demolition showed no corrosion of reinforcement that could be attributed to slag, nor is there any published evidence that such corrosion has been observed, so far as the committee is aware.

A number of changes have also been made in the table of desirable gradings for coarse aggregates, the most important of which is the change from circular openings to square openings, which is the basis on which the committee believes aggregates should be graded and specified.

The letter ballot of the committee on the revised tentative specifications resulted as follows: affirmative, 28; negative, 8; not voting, 3.

During the past two years, Sub-Committee XI on Admixtures, originally designated as the Sub-Committee on Accelerators, has conducted a cooperative series of tests on accelerators of the calcium chloride type, and its report on these tests is submitted herewith in the appendix to this report. For some reason, or perhaps several reasons, tests of accelerators do not always give as uniform results as other kinds of tests, and it may not be out of place to suggest that the general conclusions in the sub-committee report should not be assumed to hold for every possible combination of accelerators and concrete materials. On the other hand, it seems safe to assume that an accelerator which adds to the concrete mixture 2 or 3 per cent (by weight of the cement) of calcium chloride will in the very great majority of cases markedly increase the rate of early hardening. The report of the sub-committee should, therefore, be of interest and value to all users of concrete, and should encourage a wider use of accelerators under those conditions where an increase of early strength and hardness is desirable.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 544 (1921).

[2] See p. 626.—ED.

The Standard Methods of Test for Apparant Specific Gravity of Sand, Stone and Slag Screening, and Other Fine Non-Bituminous Highway Materials (D 55 – 19) specifies a form of Jackson apparatus with graduations reading to 0.01 specific gravity and has a range which is not sufficient to cover all classes of aggregates which it may be desirable to test. A modified Jackson apparatus having a range of 2.0 to 3.5 specific gravity with graduations reading to 0.01 specific gravity is acceptable for use in this test. Committee C-9 recommends to Committee D-4 on Road and Paving Materials, which committee has jurisdiction over the methods in question, that the standard methods be modified in this respect.

This report has been submitted to letter ballot of the committee, which consists of 39 members, of whom 36 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. T. GOLDBECK,
Chairman.

J. C. PEARSON,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Specifications for Concrete Aggregates referred to in this report with the modification appearing in the Summary of the Proceedings, page 36, were accepted. The specifications as thus revised appear on page 626.

APPENDIX

REPORT OF COOPERATIVE SERIES OF TESTS ON ACCELERATORS, CONDUCTED UNDER THE AUSPICES OF COMMITTEE C-9

INTRODUCTION

In the fall of 1920, Sub-Committee XI of Committee C-9 was created to study and report on accelerators for concrete. Early in 1921 the sub-committee proposed a program involving a limited series of tests by a number of laboratories on accelerators of the calcium chloride type. This program was approved by the general committee, and was in brief as follows:

A number of laboratories were to be requested to carry out a series of compression tests on 1 : 2 : 4 concrete and 1 : 2½ mortar (volume proportions) using local materials and three or more commercial accelerators. The tests were to be made in such manner as to afford a direct comparison of the strengths of the mixtures with and without the accelerators at the ages of 2 days, 7 days, 28 days, 3 months and 1 year. The purpose of the tests was primarily to determine whether the effects of any or all of the accelerators were, or were not, considerable after the 28-day period; incidentally, it was hoped that the tests would indicate whether or not different brands of cement respond in the same general manner to a given accelerator, also whether the different accelerators have different effects on a given brand of cement, and if so, whether such differences could be accounted for by differences in calcium chloride content.

COOPERATING LABORATORIES

The laboratories which offered to carry out the series of tests as outlined were as follows:

U. S. Bureau of Standards, Washington, D. C.
U. S. Bureau of Standards, Denver, Colo.
Lehigh Portland Cement Co., Allentown, Pa.
City of Philadelphia, Bureau of Surveys, Philadelphia, Pa.
Lewis Institute, Chicago, Ill.
Hydro-Electric Power Commission, Toronto, Ont., Canada.
Pennsylvania State Highway Commission, Harrisburg, Pa.
Delaware State Highway Commission, Dover, Del.
New Jersey State Highway Commission, Trenton, N. J.

Unfortunately not all of these laboratories followed the procedure outlined by the sub-committee, so that direct comparisons of results are somewhat less numerous than the list would indicate. For example, the Lewis Institute undertook a very much more extensive program than that contemplated by the committee, but the work was not laid out in such manner as to include the mixes specified in the committee's program. Detailed data from the Lewis Institute are, therefore, omitted from this report, but reference is made to the Lewis Institute results in the general conclusions reached by the sub-committee. Some of the laboratories failed to submit all their results in time to be incorporated in this report, and others departed in various ways from the fixed program. Nevertheless, in the attempt at a general analysis of results, all data that could be used are included.

MATERIALS

The accelerators were obtained from several different sources, arrangements being made with the manufacturers or distributors to contribute these materials in the quantities required by the cooperating laboratories. A condition was imposed by the committee that those manufacturers who cared to have their materials included in the tests should furnish full information in regard to the nature and composition of the accelerators. The result of this was to eliminate one or two materials that the committee had contemplated using, and to reduce the number of accelerators used throughout the tests to three. In all cases, however, one or more of the accelerators were used in different proportions, and in a few cases, accelerators from other sources were included.

It is obviously impossible in this report to list all the materials and tests thereof that were submitted with the data from the cooperating laboratories. Local aggregates of established quality were used in all cases, and as it happened, each laboratory used a different brand of cement. Besides a number of brands used in the Lewis Institute investigation, the following were included in the tests: Tidewater, Ideal, Lehigh, Pennsylvania, Pyramid, Whitehall and Bath.

GENERAL INSTRUCTIONS FOR CARRYING OUT THE TESTS

Bearing in mind the main purpose of the tests, the sub-committee laid down only general instructions that would insure in so far as possible comparable procedure in the several laboratories and elimination of extraneous variables in any one laboratory. In general, the methods followed were those outlined in the Tentative Methods of

Making Compression Tests of Concrete (C 39 – 21 T).[1] Definite instructions based on manufacturers' recommendations were given for the preparation and use of the accelerators. The desired consistency and method of curing were indicated, but greater importance was

TABLE I.—SUMMARY OF ACCELERATOR TESTS

Age	Laboratory	1 : 2 : 4 Concrete				1 : 2½ Mortar			
		A	B	C	D	A	B	C	D
2 days	Delaware	155	173	168	137	145	156	155	141
	Denver	141	135	157	...	103	108	110	...
	Lehigh B[1]	...	149	107	145	...	162	112	125
	Lehigh D[2]	...	127	141	106	...	...	...	...
	Pennsylvania	...	114	147	165	...	153	169	128
	Philadelphia	171	207	215	176	141	168	175	152
	Washington	150	170	172	127	127	127	129	109
	New Jersey	211	279	274	214	187	211	191	189
	Ontario	159	119	154	172	236	271	148	129
	Average	164	164	171	155	156	170	149	139
7 days	Delaware	128	145	144	126	109	125	121	118
	Denver	118	107	126	...	98	107	106	...
	Lehigh B	...	119	98	139	...	136	103	123
	Lehigh D	...	89	105	89	...	...	...	...
	Pennsylvania	...	129	112	128	...	112	117	99
	Philadelphia	117	138	136	114	123	132	125	118
	Washington	113	122	122	101	105	107	110	91
	New Jersey	132	158	143	128	130	146	137	140
	Ontario	113	108	107	134	128	194	126	108
	Average	120	124	121	120	116	133	118	114
28 days	Delaware	98	104	113*a*	92	111	117	113	106
	Denver	104	118	118	...	99	106	97	...
	Lehigh B	...	111	92	121	...	117	115	116
	Lehigh D	...	91	92	74	...	...	...	...
	Pennsylvania	...	113	121	101	...	101	111	90
	Philadelphia	103	100	107	96	104	105	109	97
	Washington	96	105	111	86	104	111	109	96
	New Jersey	...	...	...	...	...	...	...	...
	Ontario	95	91	88	86	125	152	99	95
	Average	99	104	105	94	109	116	108	100
3 months	Delaware	93*a*	97*a*	93*a*	96	89	98	108	90
	Denver	86	100	102	...	97	93	92	...
	Lehigh B	...	115	100	113	...	107	118	106
	Lehigh D	...	82	87	74	...	...	...	...
	Pennsylvania	...	98	116	105	...	103	98	92
	Philadelphia	117	117	118	112	120	126	145	126
	Washington	90	103	101	85	103	120	121	96
	New Jersey	...	...	...	...	...	...	...	...
	Ontario	91	91	89	87	129	138	121	112
	Average	95	100	102	96	108	112	115	104
1 year	Delaware	95	110	118	102	93	105	102	105
	Denver	107	113	121	...	76	94	83	...
	Lehigh B	...	87	78	83	...	131	132	125
	Lehigh D	...	109	82	83	...	...	...	...
	Pennsylvania	...	102	114	101	...	95	111	100
	Philadelphia	104	112	106	115	123	115	131	121
	Washington	94	104	105	87	102	122	126	97
	New Jersey	...	...	...	...	...	...	...	...
	Ontario	81	84	88	102	118	125	98	89
	Average	96	103	102	96	102	112	112	106

[1] High-Silica Cement. [2] Low-Silica Cement.

a Some of these specimens exceeded the capacity of the machine.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 579 (1921).

placed on uniformity of conditions in any one laboratory than an absolute agreement among the several laboratories.

SUMMARY OF RESULTS

The results of the tests carried out by the cooperating laboratories and included in the general program are summarized in Table I. The absolute strengths are not given, but the figures indicate the relative strengths obtained at the different ages from the mixtures containing the accelerators, on the basis of 100 for the strength of the mixtures without accelerators.

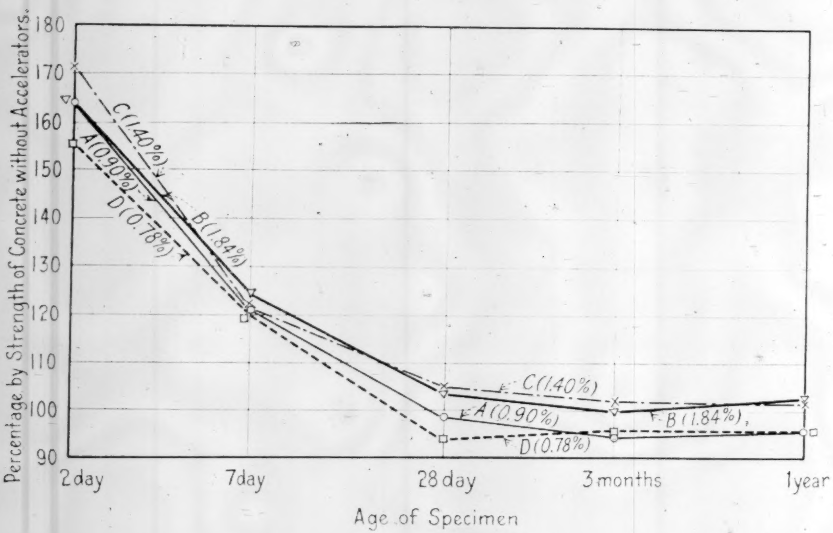

FIG. 1.—Relative Compressive Strengths of 1 : 2[a] : 4 Concrete Containing Accelerators

[a] Each curve is the average of the results obtained with the accelerator indicated thereon by letter. The figures in parentheses indicate roughly the average percentage of anhydrous chloride by weight of cement.

The accelerators are designated in the table by the letters *A*, *B*, *C*, and *D*. *A* and *B* refer to a commercial calcium chloride and are, respectively, solutions of 2 per cent and 4 per cent of the chloride as marketed, in the mixing water. *C* and *D* are proprietary materials comparing very roughly with *B* and *A*, respectively, in content of anhydrous calcium chloride.

The averages of the results given in Table I are plotted in Figs. 1 and 2, the former showing the effects of the accelerators on 1 : 2 : 4

concrete at the different ages, and the latter the corresponding effects on 1 : $2\frac{1}{2}$ mortars.

As in Table I, the letters on the curves indicate the different accelerators and the figures in parentheses indicate roughly the *average* amounts of anhydrous chloride by weight of cement.

DISCUSSION OF RESULTS

The individual results as given in Table I show a very wide range and numerous inconsistencies. However, the averages of all the results seem to establish the general conclusion that the beneficial effects of the accelerators are confined to the early ages under the prescribed laboratory conditions of curing and storage. Under these conditions the effect of the calcium chloride is to accelerate the hydration of the cement markedly during the first few days, but the resulting gain in strength largely disappears at the 28-day period and thereafter. The results of the Lewis Institute investigation substantiate this general conclusion. It will be noted, however, that the relative strengths of the mortars containing the accelerators after the 28-day period are slightly higher than those of the concretes and of the plain mortars for the later periods.

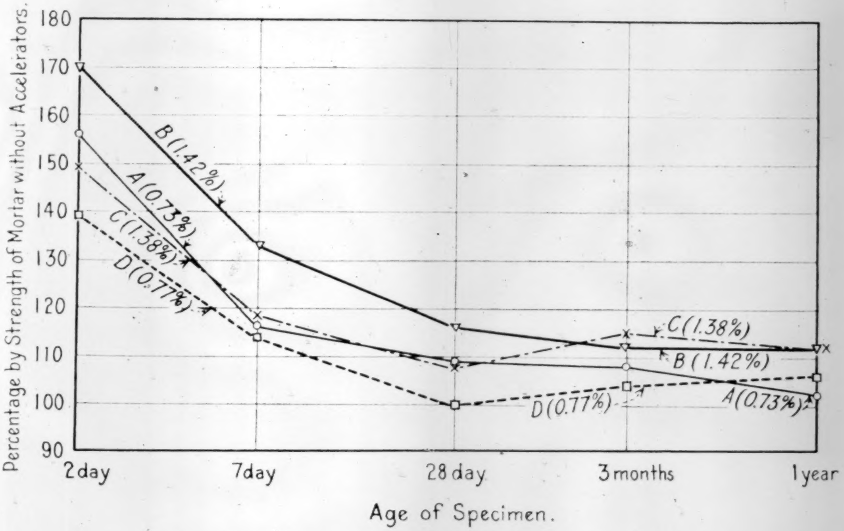

FIG. 2.—Relative Compressive Strengths of 1 : $2\frac{1}{2}$ Mortar Containing Accelerators.

Each curve is the average of the results obtained with the accelerator indicated thereon by letter. The figures in parentheses indicate roughly the average percentage of anhydrous chloride by weight of cement.

The marked differences in the results reported from the different laboratories indicate that different brands of cement respond in different degree to the accelerators but the inconsistencies in the results are sufficiently numerous to warn against drawing any positive conclusions in this respect. The Lewis Institute investigation seems to establish this fact with certainty, and affords comparative data on a limited number of cements. While the action of calcium chloride on cement is not well understood, it is to be presumed that it is effective in promoting the hydration of one or more of the main constituents of the cement, and as these constituents are known to exist in different proportions in different cements, and even in different lots of the same brand of cement, it should be anticipated that different brands or lots would respond in different degree to the action of accelerators.

In regard to the comparative effects of different accelerators, the data obtained in this investigation suggest that the acceleration of hardening is probably dependent either upon the proportion of calcium chloride to the cement, or the concentration of calcium chloride in the gaging liquid. A considerable amount of time was therefore given to an analysis of the complete data from three of the cooperating laboratories, in which the relative strengths were plotted against the two factors: ratio of anhydrous chloride to cement, and concentration of anhydrous chloride in the gaging water. Curves of the same type were obtained in both cases but the wide range of individual results made it impossible to determine to which of these two factors the relative strengths were more closely related. It would undoubtedly be of interest to know more than we do at the present time regarding the relation of quantity or strength of calcium chloride to the acceleration of the hardening of concrete, and in fact to know more about the action of calcium chloride on cement, but this information must come from a more comprehensive and carefully planned investigation. So far as the data from these tests can be interpreted, the different accelerators produce effects which are mainly dependent upon their calcium chloride content. It is not to be inferred, however, that the acceleration of hardening is directly proportional to quantity or concentration of calcium chloride, for while the range of calcium chloride content in the accelerators used in the sub-committee's tests was not sufficiently great to indicate a maximum effect upon the strength of concrete, the Lewis Institute investigation showed that such a maximum exists, on the average not much beyond the maximum concentrations employed in these tests.

In conclusion, the sub-committee would recommend that if further data were to be sought on the effects of accelerators, perhaps the information of greatest practical value would be forthcoming from their effects upon mortar or concrete at temperatures in the neighborhood of the freezing point, and also under conditions where wet curing is impracticable. Results obtained in the Lewis Institute investigation indicate that calcium chloride is more effective under dry curing than under moist curing, and this is substantiated by data from other sources. It is important also that definite knowledge be obtained regarding the effect of accelerators upon the steel in reinforced concrete. Such meager information as is available at the present time indicates that when steel is completely embedded in dense concrete, the danger of serious corrosion from the chloride is negligible, but it is doubtful whether this statement applies to all types of reinforced concrete construction under all conditions of exposure.

REPORT OF COMMITTEE C-10

ON

HOLLOW BUILDING TILE

The work on the revision of the Tentative Definitions of Terms Relating to Hollow Tile (C 43 – 21 T)[1] on which a progress report was made at the last annual meeting, has received attention during the year by Committee E-8 on Nomenclature and Definitions and Committee C-10. It is now recommended that these definitions, revised as appended hereto,[2] be accepted for publication as tentative as a revision of the present tentative definitions.

A large amount of additional information in the form of test data on the fire-resistance, resistance to freezing, strength and other properties of hollow tile from the various producing districts of the United States has been obtained from the cooperative investigation which is being conducted at the U. S. Bureau of Standards, by that Bureau and the Hollow Building Tile Association, but it is not considered advisable to recommend revisions of the Tentative Specifications for Clay Hollow Building Tile (C 34 – 21 T) based on these test results until certain phases of the work have been carried to a conclusion. It is, therefore, recommended that the Tentative Specifications for Clay Hollow Building Tile be continued as tentative.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 13 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. A. HULL,
Chairman.

EDITORIAL NOTE

The proposed revisions of the Tentative Definitions of Terms Relating to Hollow Tile, referred to in this report, with the modifications given in the Summary of Proceedings, page 32, were accepted. The definitions as thus revised appear on page 640.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol 21, p. 602 (1921).

[2] See p. 640.—ED.

REPORT OF COMMITTEE C-11

ON

GYPSUM

This has been a successful year of determined effort. The personnel of Committee C-11 has remained nearly the same, the regular schedule of three meetings has been maintained, the meetings have been well attended, and the work has been pushed forward unceasingly.

Realizing that the Society must continue to grow if it is to hold its present position in the profession, the committee has organized a new sub-committee to concentrate and enliven efforts to obtain new members.

The year's work has led to the following recommendations to the Society, relative to the specifications under the jurisdiction of Committee C-11:

Tentative Specifications for Gypsum (C 22 - 22 T).[1]—The committee is still unable to reach a satisfactory agreement as to the size of crushed and ground gypsum. The addition of a new size is being recommended by the revision of Section 3 as follows:

Section 3.—Add a paragraph to read as follows:

"No. 4.—Material of this size shall all pass a 100-mesh sieve."

The committee recommends that the tentative specifications, as revised, be continued as tentative, the letter ballot of the committee on this recommendation being as follows: Affirmative, 28; negative, 0; not voting, 5.

Standard Specifications for Calcined Gypsum (C 23 - 22).[2]—This specification at present carries a footnote to the effect that specifications for the color and plasticity of calcined gypsum will be supplied when the information is available. This information is now available, but further consideration leads us to the belief that requirements covering these properties are not necessary. It is therefore recommended that this footnote be omitted. The letter ballot of the committee on this recommendation is as follows: Affirmative, 27; negative, 2; not voting, 4.

Standard Specifications for Gypsum Plasters (C 28 - 21).—It is respectfully recommended that these specifications be submitted to the American Engineering Standards Committee for consideration as American standard, after omitting the Editorial Note at the end of these specifications, reading as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 707 (1922).

[2] 1921 Book of A.S.T.M. Standards.

> "Specifications for color of calcined gypsum for finishing coat will be formulated when sufficient information is available to warrant such procedure."

Tentative Specifications for Gypsum Plastering Sand (C 35 - 21 T).—In view of the definition of sand proposed by Committee E-8 on Nomenclature and Definitions, these specifications may have to be revised. It is therefore recommended that they be continued as tentative for another year.

Tentative Specifications for Gypsum Wall Board (C 36 - 21 T).—It is recommended that these specifications be continued as tentative pending contemplated revision.

Tentative Specifications for Gypsum Plaster Board (C 37 - 21 T).—It is recommended that these specifications be continued as tentative pending contemplated revision.

Tentative Specifications for Gypsum Partition and Furring Tile.—New Specifications for Gypsum Partition Tile or Block are submitted and it is recommended that they be accepted for publication as tentative as appended hereto.[1] The letter ballot of the committee on this recommendation is as follows: Affirmative, 26; negative, 0; not voting, 7.

Tentative Methods of Testing Gypsum and Gypsum Products (C 26 - 21 T).[2]—The principal change recommended in these methods is a definition of testing consistency for gypsum mortars. Heretofore the method of measuring consistency was given, but testing consistency was defined for neat pastes only. The detailed revisions recommended in the methods are as follows:

Section 5.—Change the first sentence to read as follows by the addition of the italicized words:

> "Place the residue obtained after drying, as described in Section 4, in a suitable flask and dissolve it in dilute HCl (not stronger than 1 : 4) in such a way that the gas evolved, *after being freed from H_2O vapor by calcium chloride or sulfuric acid,* can be collected in either soda lime or caustic potash and weighed.

Section 12.—Change the formula in Paragraph (*n*) of the note to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

$$\frac{9x}{[136]\ \mathit{145}} + \frac{36y}{172} = \text{percentage of combined water.}$$

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[1] See p. 632.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 590 (1921).

Central Heading V. Testing Consistency of Calcined Gypsum.—Omit the footnote to this central heading reading as follows:

"Specifications for testing consistency of sanded mixtures to be supplied by the committee when the information is available."

Section 16.—Change the second paragraph to read as follows by the addition of the italicized words:

"A *neat mortar* mixture is of testing consistency, if with this operation it gives a circular pat averaging 9.7 cm. in diameter, and shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the plaster."

Change the fifth paragraph of the footnote to the second paragraph to read as follows by the addition of the italicized words:

"The testing consistency *of a neat mortar* is a mixture which will give a circular pat averaging 4¾ in. (12 cm.) in diameter, and shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the plaster."

Add a new paragraph to the footnote to the second paragraph of Section 16 to read as follows:

"The testing consistency of a sanded mortar is a mixture that, when placed in a 2 by 4-in. (5.08 by 10.15-cm.) cylinder immediately removed, the slump or settlement of the sanded mixture will be ½ in. (1.27 cm.)"

Section 20.—Omit the note at the end of this section, reading as follows:

"Note.—The relative merits of the "Penetration" and "Temperature Rise" methods for determining initial and final set are being investigated by the U. S. Bureau of Standards."

Section 21.—Change the second sentence of Section 21 to read as follows by the addition of the italicized word and the omission of the word in brackets:

"Cast into a [three] *five*-gang briquette mold, of the shape and size used for testing portland cement, see the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials."

Change the second paragraph of Section 21 to read as follows by the addition of the italicized words:

"The average tensile strength shall be reported as the tensile strength of the material, except that if one or two briquettes vary more than 15 per cent from the average *of the five, they shall be discarded and* the tensile strength shall be reported as the average of the remaining specimens. *In case three or more briquettes vary more than 15 per cent from the average of the five, tests shall be continued upon three batches of five briquettes and the average of the fifteen briquettes shall be reported.* The tensile strength of all briquettes shall be reported."

Section 23.—Omit this section, together with the central heading "XII. Determination of Sand-Carrying Capacity of Calcined Gypsum," the section reading as follows:

> "23. It is the sense of the committee that sand-carrying capacity cannot be defined by tensile strength. A method of measuring sand-carrying capacity should be based upon the working quality of the plaster when mixed with varying amounts of sand. The methods adopted should be independent of the nature of surface to which the sanded mixture is applied.
>
> "This problem may be solved by measuring the relative plasticities of sanded mixtures, and the committee will have it under consideration during the coming year."

It is recommended that the methods, as revised, be advanced to standard. Committee E-1 on Methods of Testing has agreed to waive its jurisdiction in the matter temporarily, until such time as it is in a position to offer constructive criticism of these methods. The letter ballot of the committee on this recommendation is as follows: Affirmative, 21; negative, 1; not voting, 11.

Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 22 T).[1]—The committee has but one change to offer in these definitions. The definition for "Accelerator" has been changed to read as follows by the addition of the italicized word:

> "*Accelerator.*—The term accelerator shall apply to any material or substance which, when used in stucco, plaster, *mortar*, concrete, etc., will hasten set beyond the limit of testing error."

The definitions are still under consideration by Committee E-8 on Nomenclature and Definitions, and final action has not yet been taken. It is recommended, therefore, that they be continued as tentative.

The function of this Society is not only to prepare specifications, but also to develop information about materials. This year, the committee has been very active on this latter phase of the Society's work. As a result of this activity three papers are offered as appendices to this report: "The Microscopic Examination of Gypsum," by Esper S. Larsen; "Volumetric Changes of Gypsum," by J. Miller Porter; and "Fire-Resistive Properties of Gypsum," by S. H. Ingberg.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 732 (1922).

This report has been submitted to letter ballot of the committee, which consists of 33 members, of whom 27 have voted affirmatively, 2 negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

WARREN E. EMLEY,
Chairman.

V. G. MARANI,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Testing Gypsum and Gypsum Products, amended as indicated in this report, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

The proposed revisions of the Standard Specifications for Calcined Gypsum referred to in this report were accepted for publication as tentative and appear on page 965.

The proposed revisions of the Tentative Specifications for Gypsum; and of the Tentative Definitions of Terms Relating to the Gypsum Industry; referred to in this report, were accepted. The tentative standards as thus revised appear on pages 629 and 642, respectively.

The proposed Tentative Specifications for Gypsum Partition Tile or Block, referred to in this report, were accepted for publication as tentative and appear on page 632.

APPENDIX I

MICROSCOPIC EXAMINATION OF RAW AND CALCINED GYPSUM

By Esper S. Larsen

The systematic microscopic examination of gypsum products offers no great difficulties to the specialist in petrography or microscopic mineralogy and any intelligent person could be taught certain routine tests that would apply to material whose constituents are known and as few in number as are those in ordinary gypsum, just as a laboratory assistant can be taught to make simple chemical analyses. As in chemistry, such routine work should be controlled more or less by a trained microscopic mineralogist, as otherwise unexpected products or other difficulties may introduce serious errors in the results. The distinction under the microscope between substances depends on their optical and other crystallographic properties and accurate distinction requires skill if the substances have similar properties, and especially if they are in minute particles, or appear to have variable properties due to variable composition or sub-microscopic inclusions. Ordinarily, the microscope gives only qualitative results, but rough quantitative estimates can usually be made very quickly, and for many determinations, as in the determination of anhydrite in gypsum, a fair quantitative estimate can be made. The greatest value of a microscopic examination is in checking the chemical analyses and in showing the state of combination of the radicals determined by chemical analyses.

Microscopic examinations can be made on thin sections cut from fragments of gypsum rock, but this requires fragments an inch or so across and the sections represent at best only the fragments from which the slices were made so that many slices are required to represent, even approximately, an average sample of a body of heterogeneous rock. For most purposes, it is more practical to work with powders immersed in liquids of known indices of refraction. Powders ground to from 40 to 200 mesh are excellent for examination, but both finer and coarser powders can be used. For distinguishing gypsum, anhydrite, calcite, hemihydrite, and quartz, only one liquid is necessary —one with an index of refraction of about 1.550. For more refined work a larger set is desirable. The method of preparing the liquids and the method of measuring indices of refraction and other optical properties on powders are described in recent textbooks on optical crystallography.[1]

MINERALS IN RAW GYPSUM

The minerals most commonly found in raw gypsum are gypsum, quartz, anhydrite, calcite, and clay.

The more important properties that aid in determining the minerals are as follows:

Gypsum.—Gypsum ($CaSO_4 \cdot 2H_2O$) is found in grains or prismatic crystals which are monoclinic in symmetry and commonly lathlike in form, elongated parallel to c and flattened parallel to the face (010). It has a very perfect cleavage (010). It has indices of refraction, α equals 1.521, β equals 1.523 and γ equals 1.530 and a double refraction of 0.009. It has positive optic character and an axial angle of 58 deg. It has the optic orientation $Y=b$, $x=c=37\frac{1}{2}$ deg.; hence, grains or crystals lying on the cleavage face are parallel to the plane of the optic axis and show large extinction angles. It can be scratched with the fingernail. Gypsum can be readily distinguished from all other compounds found in gypsum products by its low hardness, very perfect cleavage, indices of refraction, rather low birefringence, and large extinction angle.

Quartz.—Quartz (SiO_2) is one of the common impurities in gypsum and occurs chiefly in grains. It is the only product common in gypsum that is harder than glass, and its presence can be determined from the fact that if a powder containing quartz is rubbed between two fragments of glass it will be "gritty" and will scratch the glass. Quartz has no cleavage. It is uniaxial positive and has indices of refraction appreciably higher than those of gypsum and lower than those of anhydrite ($w=1.544$, $\epsilon=1.553$). It is distinguished from the associated minerals by its hardness and lack of cleavage, its indices of refraction, and its uniaxial positive character.

Calcite.—Calcite ($CaCO_3$) is common in raw gypsum and is in many cases present in very minute crystals or grains scattered through the clay or the gypsum. Less commonly it is in large grains. It is harder than gypsum but can easily be scratched with a knife. It is characterized by very perfect cleavages $(10\bar{1}1)$ which gives rhombic cleavage pieces. Microscopically it is characterized by its very strong birefringence ($w-\epsilon=0.172$) giving rise to a white of the higher order interference color for grains of normal thickness and to bright colored specks for the minute crystals. The ω index of refraction, shown on every grain, is 1.658, while ϵ shows only on grains lying parallel to the crystal axis c and is 1.486. Calcite can be distinguished from the associated minerals by its perfect cleavage, its high interference colors and the high value for the ω index of refraction.[1]

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[1] Esper S. Larsen, "The Microscopic Determination of the Non-Opaque Minerals," U. S. Geological Survey *Bulletin No. 679*, pp. 12–24 (1921).

Anhydrite.—Anhydrite ($CaSO_4$) is common in natural gypsum and is usually found in grains of considerable size. It has a hardness near that of calcite. It is orthorhombic in crystallization and has a very perfect cleavage parallel to (001) and less perfect parallel to (010) and (100); thus cleaving into rectangular parallelopipeds. Its indices of refraction are considerably higher than those of gypsum and quartz and $\alpha = 1.570$, $\beta = 1.576$, $\gamma = 1.614$. Its birefringence is 0.044, and it therefore gives bright interference colors. It is optically $-$, and $2V = 74$ deg. The optic orientation is $X = c$, $Y = b$, $Z = a$, and all cleavage fragments give extinction parallel to the other cleavages. It is easily distinguished from the associated minerals by its cleavages, its indices of refraction, its bright interference colors, and its parallel extinction.

Clay.—Clay is a term applied to a group of hydrous aluminum silicates of which kaolinite is the commonest. The clay minerals are either amorphous or occur in very fine grains collected into aggregates or scattered through the gypsum. They nearly all have a cloudy or dirty appearance under the microscope. Their optical properties are variable and their study requires a skillful optical mineralogist. Kaolinite has indices of refraction $\alpha = 1.561$, $\beta = 1.565$, and $\gamma = 1.567$. The clay minerals can usually be distinguished by the finely crystallin character and cloudy appearance; such material is for the most part intimately mixed with quartz, calcite and other minerals.

Products in Calcined Gypsum

On calcining gypsum rock, quartz remains unchanged, as does also anhydrite. Calcite at a high temperature may be partly converted into lime (CaO) and this, on exposure to air, may be converted into calcium hydrate. The clay minerals may lose more or less water. The several compounds of $CaSO_4$ and water are very sensitive to changes of temperature and humidity and their properties and the conditions under which they form or can exist are imperfectly known. The compounds generally recognized are: Gypsum ($CaSO_4 \cdot 2H_2O$), hemihydrate ($CaSO_4 \cdot \frac{1}{2}H_2O$), soluble anhydrite ($CaSO_4$), and insoluble anhydrite ($CaSO_4$). A systematic study of these compounds by a chemist in close cooperation with an optical mineralogist is highly desirable.

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[1] If calcite is imbedded in a liquid with an index of refraction of about 1.550, most grains when turned to extinction in one direction will show considerable relief (ω), but turned to the other extinction position will show little relief. Rare grains lying nearly parallel to the base will show lower interference colors and relief for all positions.

Plaster of Paris, or gypsum calcined to the first settle and exposed to the air, is made up chiefly of calcium sulfate hemihydrate with the impurities that were in the gypsum rock—quartz, anhydrite, calcite, and clay minerals—practically unchanged. In laboratory experiments, gypsum, even when dehydrated at a very low temperature, loses all its water, but on exposure to air it quickly takes up enough water from the air to form the hemihydrate.

When gypsum is calcined at a higher temperature, soluble anhydrate is said to be formed, the calcite may be partly converted to lime or calcium hydrate, and the clay dehydrated. Such calcined gypsum may be made up of soluble anhydrite, anhydrite, quartz, calcite, lime, calcium hydrate, and dehydrated clay.

$CaSO_4 \cdot \frac{1}{2}H_2O$.—The hemihydrate formed by treating gypsum with HNO_3 is in well-formed twinned prisms with hexagonal habit and the following optical properties: opt. +, $2V$, very small to 0, α equals 1.554, β equals 1.555, γ equals 1.580. Z is parallel to the elongation. The hemihydrate formed by calcining gypsum in the usual way is in aggregates of very minute fibers matted together and replacing the gypsum grains. The fibers tend to be elongated parallel to the c crystal axis of the original gypsum and they have Z parallel to their length. The indices of refraction appear to be a little lower than those of the hexagonal crystals described above, but it is probably the same compound, and the apparent difference is due to the porosity and fine state of aggregates of the fibrous material. Calcined gypsum allowed to stand for some time tends to form coarser crystals. In a sample that had stood exposed to air for some months, each fragment had crystallized to a single individual of the hemihydrate. This hemihydrate had essentially the same optical properties as the clear hexagonal crystals precipitated from HNO_3: nearly uniaxial, optically +, α equals β equals 1.551, γ equals 1.579.

Soluble Anhydrite.—The hexagonal crystals of hemihydrate lose all their water at a low temperature and they then have the following optical properties: uniaxial +, ω equals 1.495, ϵ equals 1.552. They retain the hexagonal form, remain clear, and each crystal is a single individual. These crystals rapidly change on exposure to air to the hemihydrate, and replacement of the anhydrous form by the hemihydrate can be seen under the microscope. When gypsum is dehydrated at a low temperature, the resulting product is a mat of minute fibers of the anhydrous form described above. The examination must be made before the material has had time to take up water from the air as it very rapidly changes to the hemihydrate.

Soluble anhydrite would seem to be the suitable name for this compound but it is not certain that this is the compound that has been so named. The fact that it is so unstable on exposure to air would seem to indicate that this may be a different form.

Artificial Anhydrite.—A single sample of Keene's cement was examined. It is made up mostly of small prismatic crystals, with the following optical properties: optically +, $2V$ equals moderate, Z parallel to the elongation, α equals 1.568, β equals 1.571, γ equals 1.603. The indices of refraction are somewhat lower than those of natural anhydrite but this is probably due to the physical condition of the material and it is believed to be artificial anhydrite.

Lime.—Lime (CaO) crystallizes in rounded, isotropic grains with a very high index of refraction (1.82) and is thus easily distinguished from all the other constituents.

Calcium Hydroxide.—Calcium hydroxide is probably amorphous and occurs in isotropic grains with an index of refraction of 1.58. Due to insufficient water during hydration, it may show a strained condition which manifests itself by very low gray interference colors. Its index of refraction and isotropic character distinguish it and it is also recognized by White's calcium phenolate test.

ESTIMATION OF ANHYDRITE

The quantitative estimation under the microscope of anhydrite in raw gypsum is especially important as the chemical analyses can not be used to determine the amount of anhydrite, owing to the variable water content of natural gypsum and perhaps also of the clay minerals. The method recommended for this estimation will, therefore, be described in some detail and can be applied with slight modification for the estimation of other minerals.

Estimation by Thin Sections.—The most accurate and probably the simplest method for determining anhydrite, or any other mineral that is in crystal grains of moderate size—say over 0.1 mm. in diameter—in a gypsum rock, is by grinding enough thin sections of the rock to represent a satisfactory sample and measuring the proportion of the mineral in the section by the Rosiwal method. Some of the objections to this method are the following:

> Enough thin sections must be cut (from flat fragments about 1 in. square) to represent the material. This takes time and sections cost about 80 cents each.

> Unless great care is exercised, some of the harder minerals, such as quartz and anhydrite, may tear out in grinding and lead to erroneous results.
>
> Considerable skill is required to determine some of the mineral grains in the thin sections.

The Rosiwal method is described in books on optical mineralogy.

Estimation of Powder.—A more practical method is to use a sample of the powder pulverized to about 100 to 200 mesh. The sample of the powder as charged to the retorts is satisfactory. The only equipment needed is a petrographic microscope, or even an ordinary microscope, a few object and cover glasses, and a liquid with an index of refraction of about 1.550.

This liquid can be made by mixing by volume 77 parts of clove oil with 23 parts of cinnamic aldehyde. If kept in a carefully stoppered bottle, this liquid will remain satisfactory for several years. Its index of refraction can be checked by immersing a little powdered quartz in the liquid on a microscope slide and comparing the indices of refraction of the quartz and the liquid. To do this, a low power objective should be used, one side of the field being shaded by sliding the finger or a card into the field below the substage condenser, or by tilting the mirror. The liquid has an index of refraction of about 1.550 if most of the quartz grains show a bright bluish white border on the shaded side of the field and a dark reddish gray border on the opposite side, while a few show rather dark blue on the shaded side and bright red on the opposite side. Its index is too high and more clove oil should be added if all the quartz grains show bright borders on the shaded side without much color. Its index is somewhat low and more cinnamic aldehyde should be added if most of the grains show a blue border on the shaded side and a red border on the bright side of the field. Its index is much too low if all the grains show dark borders on the shaded side of the field.

To estimate the anhydrite, a drop of the liquid ($n=1.55$) should be placed on an object glass, a little of the sample sprinkled from a knife blade in the drop of liquid and covered with a cover glass. The grains should be evenly distributed by shifting the cover glass and the slide placed on the stage of the microscope fitted with a rather low-power objective. The liquid should just fill the space between the two glasses, and the grains, as observed with the microscope, should not be too close together. If they are packed closely together, too much powder was used.

One side of the field should be shaded by sliding the finger or card into the field beneath the substage condenser, or by tilting the mirror. All grains of gypsum will show a bright border on the shaded side of the field and a dark border on the bright side.[1] Quartz grains will show a faint bluish white to blue border on the shaded side. Clay will be in clouded aggregates which have dark grayish borders on the shaded side of the field and light grayish borders on the opposite side. Calcite grains can be distinguished by their strong birefringence, perfect cleavages, and by the fact that on revolving the stage of the microscope the grains nearly or quite disappear in some positions and stand out in marked relief in others. Most grains of anhydrite will show bright interference colors between crossed nicols and all will show a dark border toward the shaded side of the field and a bright border on the opposite side.

Each grain of anhydrite, and also of the other constituents, can thus be quickly recognized and by counting grains and estimating sizes, remembering that a third dimension is normal to the microscope slide, an approximate determination of the proportion of anhydrite by volume can be made. This may be reduced to a percentage by weight by multiplying by $1\frac{1}{4}$.

In practice it is usually true that the anhydrite grains are as large as the gypsum grains and there is no marked tendency for the anhydrite to be either more abundant or less abundant in the finer powder than in the coarse. This being true, the estimate is simplified from the fact that it is necessary only to consider the larger grains. To do this either the fines in the microscope slide are ignored or, better, some of the sample may be sifted in fine bolting cloth to get rid of the fines before mounting the sample. Sets of very small sieves can be purchased that are suitable for this purpose.

Accuracy of the Method.—The chief errors in the estimates are due to the difficulty in estimating sizes of grains, and the uncertainty in assuming that the proportion of anhydrite in the fines is the same as that in the coarser grains. Duplicate determinations made on different days by the same man checked to within 0.5 per cent for samples containing less than 5 per cent anhydrite and to within 1 per cent for samples with 10 per cent anhydrite. The actual accuracy of the determinations may be somewhat less.

Time Required.—In practice, it is best to make measurements on several slides of the powder and to average the results. The time required to make a measurement is from a few minutes to one hour, depending on the care taken and number of slides examined.

More Accurate Modification.—A more accurate estimate can be made by separating the anhydrite from a weighed amount of powder

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[1] With a strong condensing lens lowered below focus the borders will be reversed.

(1 to 10 g.) by a heavy solution, weighing both the heavy and light portions of the powder and estimating the anhydrite in both portions under the microscope as previously described. If the separation has been carefully made, the heavy portion should be made up chiefly of anhydrite. If any considerable amount of calcite is present, it can be removed by hot dilute HCl. The light portion should contain very little anhydrite. Bromoform is about the most satisfactory heavy solution to use and if pure bromoform is found to be so heavy that anhydrite will not sink satisfactorily, its specific gravity can be reduced by adding a little carbon tetrachloride or benzol. On account of the large amount of fine material in the samples, it is necessary to make a preliminary separation in a separatory funnel, drain off the heavy (settled) portion into another separatory funnel, and to repeat the separation in both funnels by shaking the sample up in more liquid. The separation may be repeated as many times as is necessary to get a clean separation. The use of heavy solutions in mineral separations is described in most textbooks on mineralogy and petrography.

This method should give more accurate results but it takes much time.

APPENDIX II

VOLUMETRIC CHANGES OF GYPSUM

BY J. MILLER PORTER

The work embodied in this research was undertaken with two objectives in mind. One was a study of the nature and magnitude of the expansion and contraction which gypsum undergoes when setting and under certain conditions after set, such as humidity, temperature, etc. The other was to study these results with the object to see if some light could not be thrown on the cause in some cases of the lack of adhesion of a gypsum-sand mix on a concrete base, making the assumption, after a preliminary study, that the lack of adhesion between the gypsum-sand mix to the concrete was not due to a chemical reaction between the gypsum and cement but rather to the differential expansion of the two materials.

The literature, while rather extensive on the expansion of gypsum during time of set, is limited in application to the present problem, due to the fact that the investigators invariably dealt only with neat gypsum and recorded very few, if any, changes in the behavior of the material due to varying amounts of water, sand, etc. After a thorough search of the literature bearing on the subject, no record could be found anywhere of an investigation where the changes due to various other causes, such as nature of base, temperature, etc., were taken into account. Even in the few articles dealing with this problem that could be found, it was evident, either from lack of proper apparatus or what not, that the results were so inconsistent that for satisfactory reasoning the work would have to be taken up from the beginning.

Work on the expansion and contraction in concrete and neat gypsum was found to be much more consistent, and of especial value was an investigation carried out by J. C. Pearson, of the U. S. Bureau of Standards, dealing with the changes in cement mortars during the time of set[1], and another by A. H. White on the volumetric changes in portland cement.[2] This latter article was particularly of interest as it dealt with the differential expansion in concrete of different mixes and brought out the fact that if the differential expansion could be made very small, it resulted in a very much stronger bond between the two concretes. From a study of the results of this latter article, and the experimental work of the writer on gypsum mixes, indications were that as the volumetric changes of the two are of the same magnitude, a gypsum plaster might be made that would have the same coefficient of expansion under the same conditions as the concrete base upon which it is applied.

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[1] "Shrinkage of Portland Cement Mortars and Its Importance in Stucco Construction," *Proceedings*, Am. Concrete Inst. (1921).

[2] A. H. White, "Volume Changes in Portland Cement and Concrete," *Proceedings*, Am. Soc. Testing Mats., Vol. XIV, Part II, p. 203 (1914).

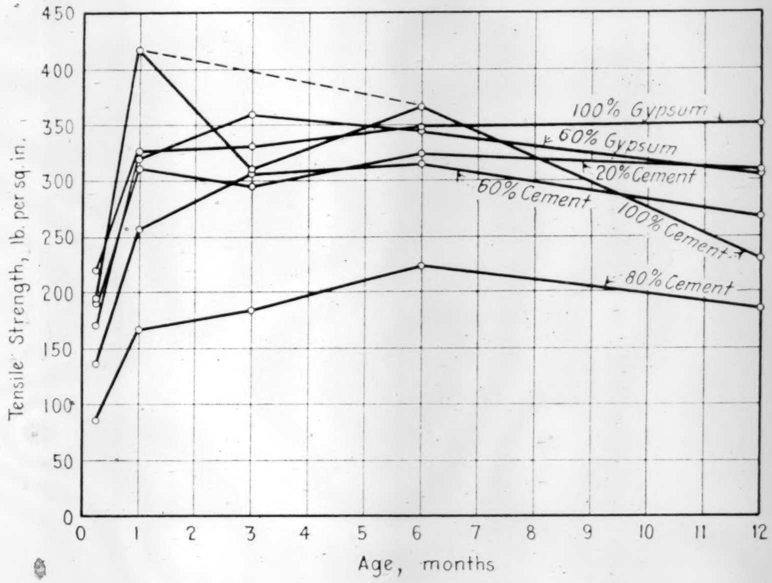

FIG. 1.—Tensile Strengths of Various Mixtures of Cement and Gypsum

Before taking up the work on expansion and contraction, it was thought that possibly the weakening of the bond between the gypsum and the concrete was due to a chemical reaction between the cement and the gypsum. In order to investigate this, briquettes were made with varying amounts of cement and gypsum, stored and then broken at one month, three months, six months and a year. One set at a year old was placed in water for several days and then dried before breaking to see if this would accelerate the reaction, if any. This set showed no material weakness from those not so treated. The results of these tests are shown graphically in Fig. 1. These do not show any weakening of the briquettes that might be attributed to a chemical reaction between the gypsum and the cement.

All of the experimental work has been carried out at the laboratories of the U. S. Bureau of Standards. For the measurements of expansion and contraction, the comparator designed for and used by Mr. Pearson in his work on cement mortars was used. It is described fully by him in his paper. It consists essentially of two microscopes mounted vertically approximately 50 cm. apart on the ends of a steel horizontal shaft in such a manner that the carriage of the instrument spans the specimen under observation and allows the cross-hairs to be focused on plugs embedded in the specimen. When the setting has been made, the horizontal shaft is rotated through an angle of 45 deg., bringing the microscopes to bear upon a graduated invar steel meter bar, upon which the distance between the marks is read directly. The instrument is capable of an accuracy of 0.005 mm. in setting and reading.

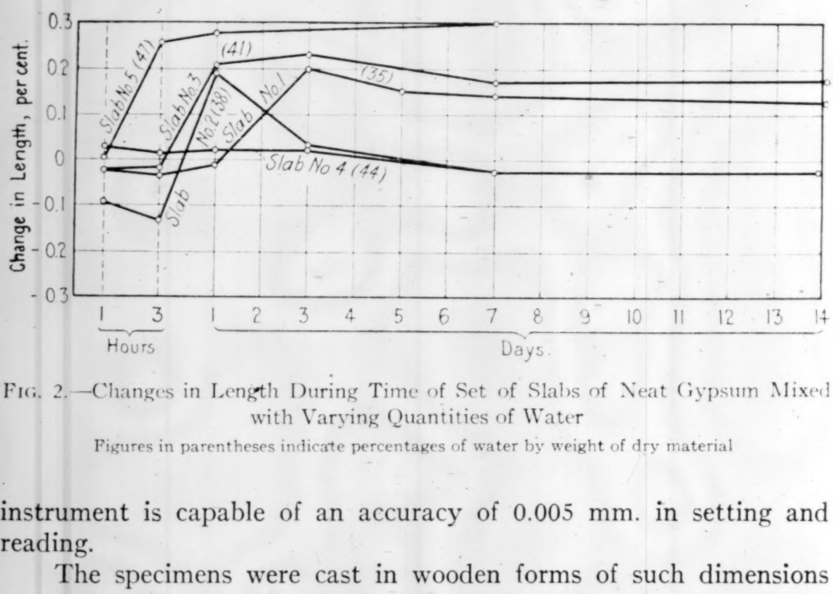

FIG. 2.—Changes in Length During Time of Set of Slabs of Neat Gypsum Mixed with Varying Quantities of Water

Figures in parentheses indicate percentages of water by weight of dry material

The specimens were cast in wooden forms of such dimensions as to give slabs of 1 by 4 by 24 in. To keep the mixes from losing water during setting, the forms were first lined with vaselined paper, and to allow for the expansion incidental to setting, pieces of felt were inserted in each end of the form box before the material was cast.

A pair of plugs made of capillary tubing were set in the mortars approximately 50 cm. apart immediately after the forms were filled and the whole then transferred to a position directly under the track upon which the comparator is mounted. In this way, observations could be started in from 3 to 5 minutes after the mixing and placing of the mortar in the forms. Readings could be taken as often as desired thereafter without disturbing the freshly molded slabs.

The work so far completed may be divided into essentially five series of slabs, the first of which was made up of neat gypsum with varying amounts of water, the second of 1 : 2 sanded mortars and varying amounts of water, the third of varying proportions of sand to gypsum and of a consistency of a $\frac{1}{2}$-in. slump in a 2 by 4-in. cylinder, the fourth of various cement mixes, and the fifth of gypsum on a cement or concrete base.

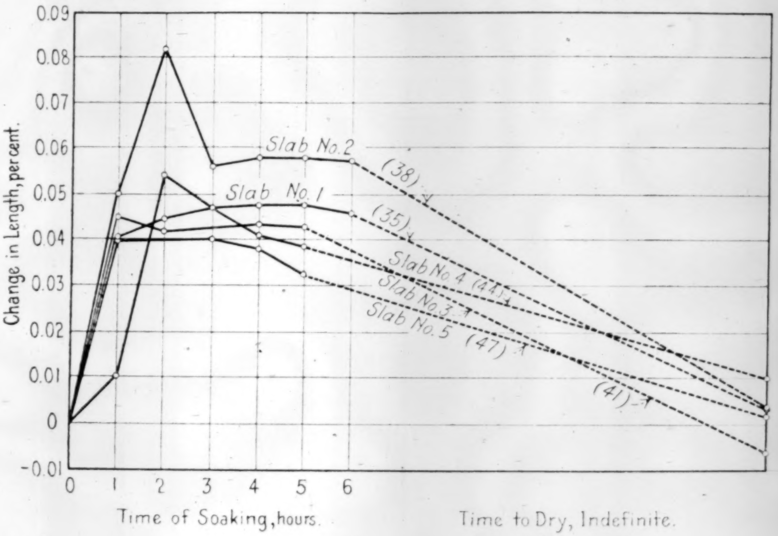

FIG. 3.—Changes in Length During and After First Soaking Subsequent to Drying of Slabs of Neat Gypsum Mixed with Varying Quantities of Water

Figures in parentheses indicate percentages of water by weight of dry material

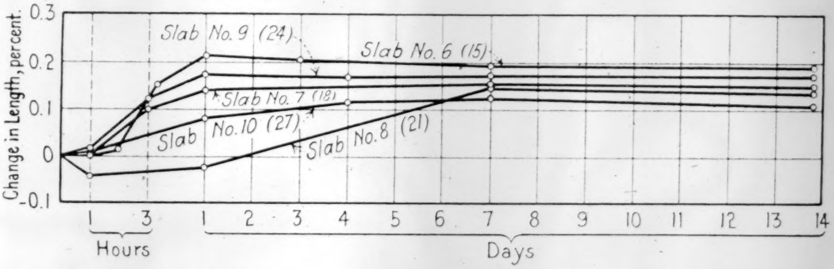

FIG. 4.—Changes in Length During Time of Set of Slabs of 1 : 2 Gypsum-Sand Mortar Mixed with Varying Quantities of Water

Figures in parentheses indicate percentages of water by weight of dry material

The materials used were unretarded gaging plaster from the Oakfield, N. Y., plant of the U. S. Gypsum Co., Potomac River sand from which the silt and salts had been washed, commercial retarder and tap water. All the slabs were retarded to set in two hours. The cement used in the composite slabs was Hercules portland cement and the sand and gravel, Potomac River.

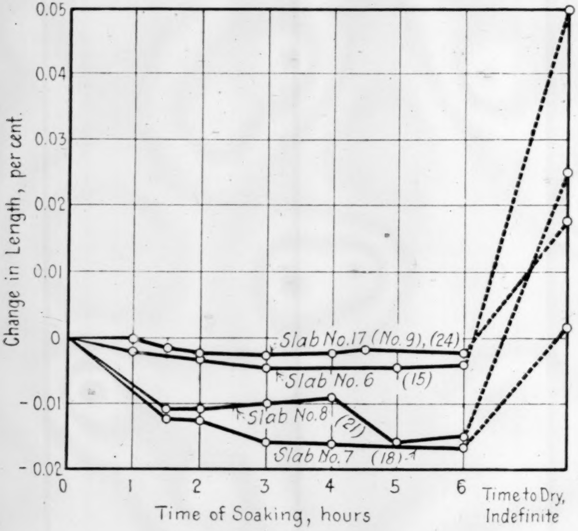

FIG. 5.—Changes in Length During and After First Soaking Subsequent to Drying of Slabs of 1 : 2 Gypsum-Sand Mortar Mixed with Varying Quantities of Water. (Slab No. 17 is a duplicate of Slab No. 9)

Figures in parentheses indicate percentages of water by weight of dry material

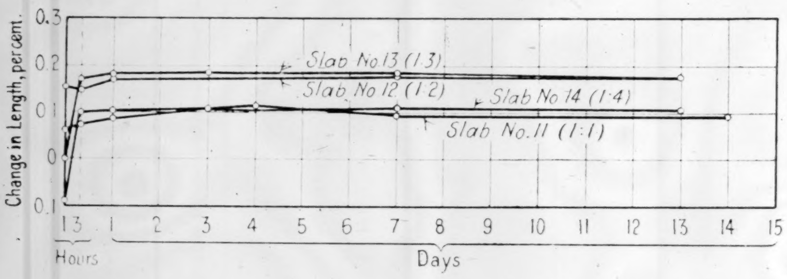

FIG. 6.—Changes in Length During Time of Set of Slabs of Various Mixtures of Gypsum and Sand, Mixed with Water to Normal Consistency

In Fig. 2 are given graphically the results of the change in length during the time of set and for the first seven days, of the neat gypsum mixtures. It will be noticed that in four of the five slabs during the first three hours there is a slight contraction, after that for about three days there is a continued increase in length, then for the next two days there is a slight decrease and after that the length remains constant. It may also be seen from a study of the curves that the slab with the greatest amount of water expanded the most and after becoming constant, still had the greatest length change.

Fig. 3 shows the results obtained by soaking the same slabs after they had become thoroughly dry. It will be noticed that slab No. 2 expanded more than slab No. 1, and slab No. 4 more than slab No. 3. In each of these cases, the slab with the greatest amount of water expanded the most. Why slabs No. 3 and No. 4 did not both give a greater expansion than either No. 1 or No. 2, I do not attempt to explain.

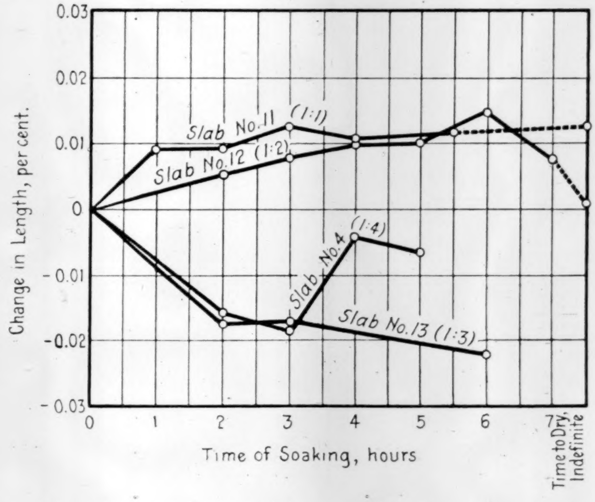

FIG. 7.—Changes in Length During and After First Soaking Subsequent to Drying of Slabs of Various Mixtures of Gypsum and Sand, Mixed with Water to Normal Consistency

Fig. 4 gives the behaviour in setting of the 1 : 2 sanded slabs with varying amounts of water. In these, it is seen that the slab containing the greatest amount of water gave the least expansion—just the reverse from the behaviour of the neat gypsum slabs. Also it appears that with one exception (No. 8) there does not seem to be a contraction at any time, either at first or after several days, but from the very first there was manifested a gradual increase in length until at about four days, after which no change is noted.

Fig. 5 shows the changes when the slabs of Fig. 4 are soaked for the first time. There appears to be in every case a slight decrease in length for about four hours, after which constancy is reached.

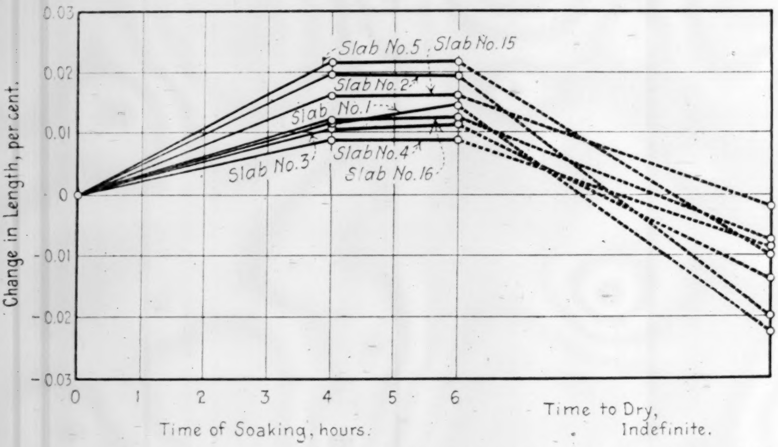

FIG. 8.—Changes in Length During and After Second Soaking of Slabs of Neat Gypsum Mixed with Varying Quantities of Water

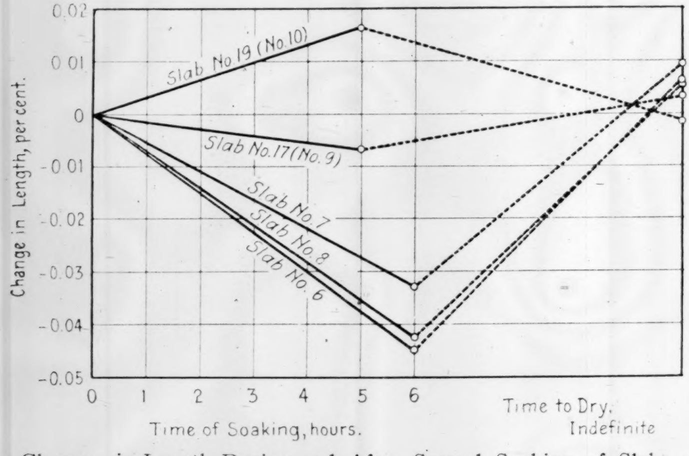

FIG. 9.—Changes in Length During and After Second Soaking of Slabs of 1 : 2 Gypsum-Sand Mortar Mixed with Varying Quantities of Water. (Slabs Nos. 17 and 19 duplicates of Slabs Nos. 9 and 10, respectively)

It will be noticed that (ignoring No. 7) the smaller the quantity of water used in mixing, the greater will be the final expansion.

Fig. 6 shows graphically the changes occurring for the first thirteen days in slabs of varying proportions of sand made up to a consistency of ½-in. slump in a 2 by 4-in. cylinder. Constantcy is reached in about one day after mixing, the slab having the greatest percentage of sand showing the greatest expansion.

In Fig. 7 are given the results of wetting the slabs shown in Fig. 6. These curves bring out some very interesting results: namely, the possibility of control of the expansion and contraction by the gypsum content and the ability from this to make a plaster that upon becoming damp or wet will either expand or contract as desired. From the curves we see that slabs of 1 : 1 and 1 : 2 proportions of gypsum to sand expand upon wetting, while those of a higher percentage of sand, say 1 : 3 or 1 : 4, contract. The 1 : 3 and 1 : 4 proportions proved to become so weak after a thorough wetting that they broke in handling after five and six hours, respectively, but from the data obtained we were able to predict that the behavior of the slabs as to the changes expected would be quite similar upon successive wettings although the changes would become less in magnitude.

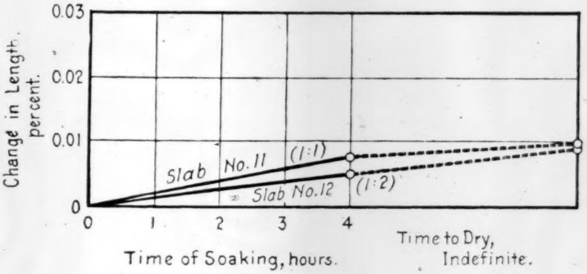

FIG. 10.—Changes in Length During and After Second Soaking of Slabs of Various Mixtures of Gypsum and Sand, Mixed with Water to Normal Consistency

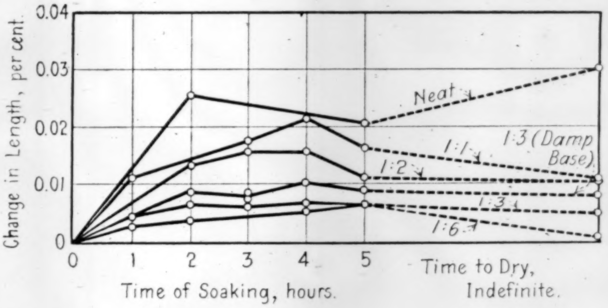

FIG. 11.—Changes in Length During and After First Soaking of Slabs of Portland Cement Mortars

After allowing the slabs to thoroughly dry they were again immersed in water and the results so obtained are shown in Figs. 8, 9 and 10. It will be seen from these that the magnitude only of the change is altered and not the general characteristics of the curves. If the slab had expanded on the first wetting, on the second wetting the expansion was not so great. For a few slabs this wetting was repeated several times, but the results obtained on the second wetting were indicative of the results obtained on several wettings, so the repeated wettings were discontinued.

After the results of the gypsum slabs were studied, several typical slabs of cement were subjected to the same conditions. The results are shown in Fig. 11. These slabs had been previously tested to determine the changes during the time of set and were thoroughly set and dry when immersed in water. The composition of these slabs and the manner in which they were cast is given in Table I.

TABLE I.—COMPOSITION OF CEMENT MORTAR SLABS

SLAB	COMPOSITION	NATURE OF BASE WHEN POURED	EXPANSION AFTER WETTING AND DRYING, PER CENT
No. 51	Neat Cement	On water-tight base	0.0304
No. 53	1 : 1 Sand and Cement	" " " "	0.0112
No. 64	1 : 2 " " "	" " " "	0.0102
No. 27	1 : 3 " " "	" " " "	0.0090
No. 131	1 : 3 " " "	On Damp base	0.0112

A study of the curves of Fig. 11 leads to some interesting results. It will be noticed that to reach their maximum increase takes approximately three to four hours' immersion. This is slightly longer than is the case with gypsum. Also it is seen that an increase in sand content gives a decrease in expansion. Taking as a typical wall, a 1 : 6 mix or rather a 1 : 2 : 4 mix and then studying the curves of the gypsum mixes, it is obvious that the 1 : 2 gypsum and sand slab under the same conditions shows a change of the same magnitude. With this as the basis for further investigations, a composite slab of a 1-in. layer of 1 : 6 concrete upon which was poured a 1 : 2 gypsum mix was made and allowed to set and dry and this subjected to the wetting process. How they behaved with respect to each other may be seen from the curves of Fig. 12. In interpreting these it must be borne in mind that the maximum deviations either in the points as plotted or the curves are in the range of mechanical error or the personal equation. This slab was repeatedly wetted, and other slabs made to check this one checked very closely. After several wettings there was no noticeable weakening of the bond.

In applying the coat of gypsum to the concrete, plastering practice was followed as closely as possible. The concrete was set and dry and then cleaned and dampened with a sufficient amount of water so as to not draw the water out of the gypsum.

SUMMARY

It is evident from a study of the results obtained in the gypsum-cement briquettes that there is little basis for the assertion that there is a chemical reaction between the gypsum and the cement in a concrete wall and there seems to be no substantiating evidence that this is the cause for the lack of adhesion between the two materials.

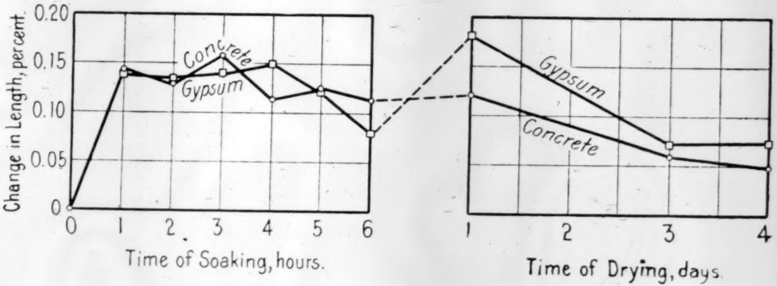

FIG. 12.—Changes in Length During and After First Soaking of Composite Slab of 1 : 6 Concrete and 1 : 2 Gypsum

In the case of the plasters made of gypsum it is possible, by varying the components, to control the behavior so as to get either expansion or contraction as desired.

In a concrete submitted to wetting, the greater the percentage of cement the greater the expansion.

From a consideration of the foregoing, it is not too much to expect that with any concrete, a study of its characteristics will make it possible to make up a gypsum plaster so that the differential expansion between the cement or concrete and the gypsum plaster is of such a small magnitude as to be negligible and so that the maximum strength may be developed in the bond.

APPENDIX III

THE FIRE RESISTIVE PROPERTIES OF GYPSUM

BY S. H. INGBERG

THERMAL PROPERTIES AND EFFECTS

Molecular Changes.—Gypsum products are made of hydrated gypsum of the formula $CaSO_4 \cdot 2H_2O$ plus varying amounts of free water, to which, in addition to the constituents other than hydrated calcium sulfate present in the gypsum itself, various fillers or reinforcements such as sand, cinder, wood fiber, or metal may be added. On application of heat, the free water is driven off and, under normal saturated vapor pressure at 107° C., three-fourths of the combined water is liberated according to the formula:

$CaSO_4 \cdot 2H_2O$ + heat (22.7 calories per gram) = $CaSO_4 \cdot \frac{1}{2}H_2O + \frac{3}{2} H_2O$.

Practically, this change takes place over a wide temperature range, depending on the constituents in the gypsum and the conditions of calcination. The hemi-hydrate formed is analogous with plaster of Paris which is the base of most gypsum plasters. At higher temperatures, the remaining combined water is driven off and soluble or insoluble anhydrate is formed, depending on the temperature and duration of exposure. The breaking up of the anhydrite according to the formula,

$$CaSO_4 + \text{heat} = CaO + SO_3$$

does not occur below 1300° C. for pure calcium sulfate but may take place at as low a temperature as 1000° C. with the impurities present in some gypsum rocks.

The temperature rise in normal gypsum products exposed to fire is retarded by the heat consumed in the reactions outlined and consequent evaporation of liberated water. The change from the hydrated to the anhydrous condition involves a heat consumption of about 173 calories per gram of $CaSO_4 \cdot 2H_2O$ assuming a temperature rise of 150° C. for completing the process. Of this amount, less than 20 per cent is required to heat the material through the given temperature range, the remainder being heat consumed in the changes in crystallin structure and latent heat of evaporation of the liberated water. Outside of the heat insulating properties of the uncalcined and calcined material as such, the above is the principal cause of the slow temperature rise through the thickness of the material when exposed to fire on one side.

Structural Effects.—The molecular changes outlined above are accompanied by a shrinkage that produces a fissured structure with impaired strength and heat insulating properties. As the amount of incombustible filler is increased, the shrinkage effects become less pronounced. It is thus seen that while the addition of the filler decreases the initial heat insulating properties due to the smaller amount of gypsum present in the mixture, there is a gain in the insulating properties after dehydration since the structure is less open and fissured.

PROPERTIES OF GYPSUM AS FIRE PROTECTIVE COVERING FOR COLUMNS

Used as a protection for columns, gypsum exhibits quite uniformly the characteristics outlined as general fire retardant properties of the material. The requirements are heat insulation, some degree of hardness and strength to withstand impacts and abrasions incident with ordinary use, stability under fire conditions, and ability to withstand accidental hose stream applications after moderate fire exposures.

Heat Insulation.—The author calls attention to the results of the jointly conducted fire tests of building columns[1] wherein solid gypsum coverings built of blocks were tested as protection for steel columns, and to fire tests of concrete columns by the U. S. Bureau of Standards[2] where gypsum of poured monolithic form and as plaster was employed.

The heat insulation afforded steel columns by the solid block protection was effective in keeping the general temperature of the column steel below 150° C. (302° F.) up to the point where the protection began to fall off due to shrinkage effects. Considering that steel does not lose appreciable strength below 400° C. (752° F.) and that steel columns do not generally fail under working load at temperatures below 600° C. (1112° F.), it is seen that on this score an ample margin of protection was afforded. The blocks were plain unreinforced partition blocks, cut to the necessary size. Metal ties, corrugated iron strips or wire mesh, were placed in the horizontal joints over the vertical joints between blocks.

Reinforced concrete columns protected by gypsum, or mixtures of gypsum and other materials, a little over 2 in. thick, as molds reinforced with wire, withstood a 4-hour fire exposure with an indicated loss of strength of not over 25 per cent as tested cold after fire exposure. Where not reinforced, failure of the covering due to shrinkage effects took place before the end of the fire test. Applied as plaster, somewhat less protection was given, due apparently to smaller effective thickness of covering.

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[1] Jointly conducted by Factory Mutual Laboratories, Underwriters' Laboratories, and the U. S. Bureau of Standards. Complete reports "Fire Tests of Building Columns" are obtainable from Underwriters' Laboratories and Bureau of Standards.

[2] See "Fire Tests of Concrete Columns," Am. Concrete Inst., 1918, 1919, 1920.

Resistance to Water Application.—The water generally carries away material or units damaged during the preceding fire exposure. The fire and water tests of protected steel columns indicated that 2-in. block protection will generally remain in place for periods between one and two minutes under hose stream applications of moderate intensity. The 4-in. protections remained in place during a 5-minute application of water at higher pressure. While the test equivalents of accidental water applications during the extinguishment of fires in buildings is difficult to estimate, it seems that the factor of safety of unreinforced and otherwise unsecured block protections is not large as applied to the smaller thicknesses, and that substantial increased security would be given if reinforced or otherwise adequately tied.

Heat Effects on Structure, Strength, and Stability.—As column covering, gypsum develops characteristic shrinkage effects and loss of strength on exposure to fire, which somewhat limits the heat insulating properties unless special provisions are made. As it concerns block coverings, the outer exposed portion of the block shrinks, loses strength and supporting power, resulting in tipping out and dislodgment of blocks. Metal ties in the joints are ineffective in preventing this, since the shrinkage causes them to lose hold. Blocks with a continuous tongue and groove in the horizontal joint should be more stable than with plain joints, particularly if a continuous metal tie be imbedded in the groove. A monolithic poured construction properly reinforced would probably be the most effective. Metal ties should be covered from ½ to 1 in. Exposed at temperatures generally obtained in fires, gypsum and iron fuse readily.

Balancing Heat Insulation and Shrinkage.—Since the full value of the heat insulating properties of neat gypsum applied as column covering is attained with difficulty due to the shrinkage effects, it may be possible to attain a balance between these properties by addition, at the expense of some loss in insulating value, of materials of smaller shrinkage, provided the necessary strength is obtained. A considerable number of such combinations have been used in various gypsum constructions, including besides sand, cinders and ashes of proper quality, also minor additions of lime and kieselguhr.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials has held two meetings during the past year. At the first meeting, held in Philadelphia on October 3, 1922, thirty-six members were present. Various matters which had been considered by the Advisory Committee were presented and progress reports received from the numerous sub-committees. On April 5, 1923, the second meeting of the year was held at Philadelphia, there being present 43 members. The present total membership of the committee is 141.

During the past year Committee D-1 has been very active and as a result a number of the old specifications have been revised, new standards suggested, and work along progressive lines carried out. Of the various activities, the following should be mentioned:

Sub-Committee III on Testing of Paint Vehicles recommends that the Tentative Specifications for Perilla Oil (D 125 - 22 T) be advanced to standard, and that the Tentative Specifications for Tung Oil (D 12 - 22 T) be revised and continued as tentative.

Sub-Committee VI on Definitions of Terms Used in Paint Specifications recommends new tentative definitions for the terms "toughness" and "elasticity" of paint and varnish films.

Sub-Committee VIII on Methods of Analysis of Paint Materials recommends that the Tentative Methods of Routine Analysis of Pigments (D 126 - 22 T) be revised and advanced to standard, and also recommends a new tentative method of test for specific gravity of pigments for publication as tentative.

Sub-Committee IX on Varnish recommends new tentative methods of testing varnish, including the Kauri Reduction Test, Appearance, Color and Non-volatile Matter.

Sub-Committee XIII on Shellac proposes new tentative methods for testing shellac, including tests for rosin, alcohol insoluble and moisture, to replace when adopted the present Standard Methods of Testing Shellac (D 29 - 17).

Sub-Committee XIV on the Preparation of Iron and Steel Surfaces for Painting reports additional inspections of the test panels at Altoona, Pa., and Brooklyn, N. Y., and includes with its report, photographs of the Brooklyn panels. No definite recommendations are made.

Sub-Committee XVIII on Physical Properties of Paints reports progress without making any definite recommendations.

Sub-Committee XXIII on Anti-Fouling Paints reports the results of anti-fouling tests made during the year 1922 and accompanies the same with photographs illustrating the inspection results.

Full details of the work of the various sub-committees are presented as a part of this report.

The recommendations contained in this report have been submitted to letter ballot of the members with the following result:

Items	For	Against	Not Voting
Report of Sub-Committee III on Testing of Paint Vehicles, including the advancement to standard of the Tentative Specifications for Perilla Oil (D 125 - 22 T)	40	1	23
Revisions of the Tentative Specifications for Raw Tung Oil (D 12 - 22 T)	43	0	21
Report of Sub-Committee VI on Definitions of Terms Used in Paint Specifications, including the Tentative Definitions for			
Toughness	41	8	15
Elasticity of Paint and Varnish Films	42	13	9
Report of Sub-Committee VIII on Methods of Analysis of Paint Materials including the advancement to standard of the revised Tentative Methods of Analysis (D 126 - 22 T)	50	0	14
Tentative Method of Specific Gravity of Pigments	49	0	15
Report of Sub-Committee IX on Varnish, including the Tentative Methods of Testing Varnish	29	0	35
Report of Sub-Committee XIII on Shellac, including the withdrawal of the Standard Methods of Testing Shellac (D 29 - 17)	44	1	19
Tentative Methods of Testing Shellac	45	1	18
Report of Sub-Committee XIV on Preparation of Iron and Steel Surfaces for Painting	52	0	12
Report of Sub-Committee XVIII on Physical Properties of Paint Materials	51	0	13
Report of Sub-Committee XXIII on Anti-Fouling Paints	47	0	17

This report has been submitted to letter ballot of the committee, which consists of 141 members, of whom 64 have voted affirmatively, none negatively, and 77 have refrained from voting.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

R. L. HALLETT,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Perilla Oil; and the Tentative Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments, and Chrome Green, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

The proposed revisions of the Standard Methods of Testing Shellac were accepted as new tentative methods and appear on page 658. The proposed revisions of the Standard Definitions of Terms Relating to Paint Specifications referred to in this report were accepted for publication as tentative and appear on page 975.

The proposed revisions of the Tentative Specifications for Tung Oil referred to in this report were accepted as further revisions of the Standard Specifications for Purity of Raw Tung Oil. The tentative specifications as thus revised appear on page 644.

The proposed Tentative Methods of Testing Oleo-Resinous Varnishes; and the proposed Tentative Method of Test for Specific Gravity of Pigments, referred to in this report, were accepted for publication as tentative and appear on pages 651–657.

There is unanimous agreement of the sub-committee that the present Tentative Specifications for Perilla Oil, Raw or Refined (D 125 - 22 T)[1] should be advanced to standard, and this is accordingly recommended.

The present Tentative Specifications for Soya Bean Oil, Raw or Refined (D 124 - 22 T), are satisfactory. It has been suggested, however, that before advancing these to standard, further work be done to develop a heat or "break" test for soya bean oil, which will indicate its quality for varnish making operations. Suggestion has also been made that the iodine number be lowered to 126. This suggestion is worthy of consideration, since the production of soya bean oil in America is rapidly growing, and several samples of American produced oil that have been examined showed iodine values below 128. It is recommended, therefore, that the present specifications for soya bean oil be continued as tentative.

The sub-committee recommends that the Tentative Specifications for Raw Tung Oil (D 12 - 22 T)[2] be revised as follows:

Section 1.—Change the minimum requirement for specific gravity from 0.939 to 0.9400; change the minimum requirement for refractive index at 25° C. from 1.515 to 1.5165; and change the maximum requirement for acid number from 7 to 8.0.

Section 3.—Add a paragraph on quality or open-pan heat test to read as follows:

"*Quality Test.*[3]—Into an ordinary agateware casserole, having a bottom diameter of 3 in., weigh 150 g. of the tung oil to be tested, and set the casserole on a wide-flanged tripod having a 3-in. opening. The object of the flange is to prevent super-heating of the sides of the casserole. Heat rapidly with a full Bunsen flame, stirring with a thermometer, until the heat reaches 540° F. (282.2° C.). Turn down the flame and hold the heat as near 540° F. (282.2° C.) as possible, stirring with the thermometer, until on lifting the latter the oil drops with a pronounced string, showing that polymerization has started. The time required after reaching 540° F. (282.2° C.) until the string is noted, is the time of the heat test. For pure tung oils this will not exceed eight minutes. As soon as the oil strings, remove the lamp and the thermometer, and stir with a stiff spatula until the oil is solid. After stringing, a pure tung oil will require not over 40 seconds more to become solid. When solid, allow to stand just one minute, then turn out, upside down, on clean paper and cut with a clean spatula. Pure tung oil gives a gel that is dry, not adhering to the spatula when cut, that is firm, crumbling under pressure of the spatula without sticking, and the cut portions should crumble under pressure like dry bread crumbs. Adulterated tung oil gives a gel that is soft, sticky, and which will not crumble."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 753 (1922).

[2] *Ibid*, p. 742.

[3] Furnished by R. S. Worstall.

There was sent out to a number of the observers a sample of commercial tung oil representing large shipments that have come into this country, and that have proved satisfactory in actual paint and varnish making operations. A sample of this material examined by the chairman met all requirements of the American Society for Testing Materials. The results of analyses in laboratories of various operators are given in Table I. The chairman has put up in small labelled cans a number of samples of this oil, and will be glad to forward them to those interested. These samples may be used for control in judging the value and determining the constants of samples of unknown quality.

TABLE I.

Observer	Iodine No.	Saponification No.	Unsaponifiable Matter, per cent	Heat Test, A.S.T.M., minutes	Specific Gravity at 15.5° C.	Acid No.	Refractive Index at 25° C.
Gardner	164.6	192.3	0.47	12	0.9418	4.8	1.5178
Lindsay	163.0	194.5	....	11½	0.941	...	1.5171
Bureau of Standards	163.1	192.2	0.65	11¼	0.9419	4.7	1.5178
N. Y. Produce Exchange (Trevithick)	165.5 (1 hour)	192.8	0.43	11½	0.942	4.8	1.5177
Hallett	166.1	192.4	0.42	10½	0.9423	4.1	1.5177
Hall-Forsyth	162	192.4	0.40	9	0.9421	4.2	......
Average	164.0	192.8	0.47	11	0.9418	4.5	1.5176

Methods of sampling tung oil may be developed during the coming year, and will then be added to the Tentative Specifications for Raw Tung Oil.

Respectfully submitted on behalf of the sub-committee,

H. A. GARDNER,
Chairman.

REPORT OF SUB-COMMITTEE V ON LINSEED OIL

The work of Sub-Committee V during the year has been upon the determination of the amount of foots in raw linseed oil. Nine samples of oil which had been given certain heat treatments were examined in accordance with the method described in the Tentative Specifications for Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed (D 51 – 18 T) of the Society and also in accordance with a modification of this procedure, devised by Mr. George Sutherland, which involves the use of Babcock cream bottles and the centrifuge.

The samples of oil under investigations were as follows:

Sample No. 47.—A sample of old South American raw linseed oil.
Sample No. 48.—A sample of South American raw linseed oil, high in foots.
Sample No. 49.—A sample of South American raw linseed oil, fresh oil of commerce.
Sample No. 50.—A sample of South American raw linseed oil, fresh oil of commerce.
Sample No. 51.—A sample of old South American raw linseed oil.
Sample No. 52.—A sample of South American raw linseed oil, high in foots.
Sample No. 53.—A sample of old North American raw linseed oil.
Sample No. 54.—A sample of North American raw linseed oil, high in foots.
Sample No. 55.—A sample of North American raw linseed oil, fresh oil of commerce.

The following directions were sent with these samples:

"There are nine samples of oil representing qualities that might be found in commercial raw linseed oil except the three marked 'abnormally footy.'

"On all of these samples as received, you will please run a foots test by the A.S.T.M. method, which is as follows:

"The following reagents are required:

"(a) Acetone that will pass U. S. Pharmacopeia specifications.

"(b) Add $CaCl_2$ solution, made by saturating with $CaCl_2$, a mixture of 90 parts of water and 10 parts of concentrated HCl, sp. gr. 1.2, at room temperature.

"With all materials at a temperature between 21 and 27° C. (70 and 80° F.) mix by shaking in a stoppered flask for exactly one minute, 25 cc. of the well-shaken sample of oil, 25 cc. of acetone, and 10 cc. of the acid $CaCl_2$ solution. Transfer the mixture to a burette where settling can take place for 24 hours. The temperature during this period should be between 21 and 27° C. (70 and 80° F.). The volume of the strata lying between the clear calcium-chloride solution and the clear acetone and oil mixture is read in tenths of a cubic centimeter or fraction thereof. This reading multiplied by four expresses the amount of foots present as percentage by volume of the oil taken.

"Then chill the balance of the oil by putting out-doors at a temperature near freezing or else in an ice and water mixture for at least twelve hours.

"When the chilled oils have reached room temperature, make another foots determination. Warm another portion of the chilled sample in a water bath to a temperature of 65.5° C. (150° F.), allow to cool to room temperature and then make another foots determination.

"In an endeavor to eliminate the inaccuracies he noted in using the above-described method, Mr. George Sutherland, of Chicago, devised the following modification:

20 cc. Oil
20 cc. Acetone
8 cc. Acid $CaCl_2$ solution.

"Measure the oil into a Babcock cream bottle. Wash the oil adhering to the graduated neck of the bottle into a Babcock bottle with the acetone. Measure 8 cc. of acid $CaCl_2$ solution into a Babcock bottle, stopper and shake for exactly one minute.

"Centrifuge at 1000 r.p.m. for exactly one minute. Pipette off the clear oil-acetone liquid to within about 5 mm. of the foots layer. Add $CaCl_2$ solution until the liquid level is within about 2 cm. of the top of the stem. Centrifuge for exactly one minute at 1000 r.p.m. Pipette off the clear liquid and add $CaCl_2$ solution until foots are above the lowest calibration in the stem. Centrifuge for one minute and read. Each unit represents a close approximation of 0.2 cc. so that one unit represents 1 per cent of foots.

"If you have no centrifuge running at 1000 r.p.m., use the one you have and record the speed in your report."

The following have reported results:

Mr. P. R. Croll, Pittsburgh Plate Glass Co., Milwaukee, Wis.
Mr. G. H. Pickard, Midland Linseed Products Co., Minneapolis, Minn.
Mr. L. L. Steele, U. S. Bureau of Standards, Washington, D. C.
Mr. C. B. Mills, National Lead Co., Brooklyn, N. Y.
Mr. George Sutherland, Armstrong Paint and Varnish Co., Chicago, Ill.
Mr. J. E. Booge, E. I. du Pont de Nemours and Co., Wilmington, Del.
Mr. R. D. Bonney, Congoleum Co., Marcus Hook, Pa.

The results of the investigation are given in Table I.

In studying these figures, one must bear in mind the fact that the natural and chilled oils are, in all probability, in the same condition so far as temperature change effect is concerned because the samples were undoubtedly chilled during transportation. This condition accounts for the closeness of the average percentages of foots as given in the first two columns of Table I, which represent the percentage of foots as found on the natural and on the chilled samples.

The heating of the samples produces a marked lowering of the percentage found on all samples save No. 48. This oil was stored in a warm place thus causing the dissolved cellular material to precipitate while the solid fats did not. Therefore, chilling produced but slight effect, a fact which emphasizes the justice of the heating procedure,

TABLE I.—RESULTS OF TESTS ON DETERMINATION OF FOOTS IN LINSEED OIL

Observer	Method of Test					
	A.S.T.M. Natural	A.S.T.M. Chilled	A.S.T.M. Chilled Heated	Sutherland Natural	Sutherland Chilled	Sutherland Chilled Heated
			SAMPLE NO. 47			
Croll	0.8	1.2	1.2	....	....	....
Pickard	1.2	1.4	0.1	0.47	0.47	0.20
Steele	1.4	1.9	0.26	0.40	....	....
Mills	1.2	1.4	Trace	0.30	0.30	Trace
Sutherland	1.7	....	....	0.50	....	....
Booge	....	....	....	....	....	....
Bonney	2.4	2.6	0.8	....	....	....
Average	1.45	1.7	0.6	0.4	0.4	0.20
Maximum	2.4	2.6	1.2	0.50	0.47	0.20
Minimum	0.8	1.2	0.1	0.30	0.30	0.20
			SAMPLE NO. 48			
Croll	9.6	13.2	11.2	....	....	....
Pickard	8.8	8.6	10.4	4.7	6.5	7.0
Steele	9.4	8.8	9.1	4.3	....	....
Mills	8.0	10.0	8.4	8.8	3.4	3.0
Sutherland	9.0	....	....	4.5	....	....
Booge	11.9	6.8	7.4	3.7	4.5	5.5
Bonney	6.8	7.6	6.8	....	....	....
Average	9.1	9.2	8.9	4.0	4.8	5.2
Maximum	11.9	13.2	11.2	4.7	6.5	7.0
Minimum	6.8	6.8	6.8	2.8	3.4	3.0
			SAMPLE NO. 49			
Croll	1.6	1.6	1.2	....	....	....
Pickard	2.6	1.7	0.66	1.0	0.7	0.37
Steele	2.0	1.6	0.8	0.43	....	....
Mills	0.8	1.2	0.6	0.2	0.3	0.2
Sutherland	2.4	....	....	0.5	....	....
Booge	1.2	1.0	0.6	0.3	0.5	0.1
Bonney	1.8	1.8	1.2	....	....	....
Average	1.8	1.5	0.8	0.5	0.5	0.2
Maximum	2.6	1.8	1.2	1.0	0.7	0.37
Minimum	0.8	1.0	0.6	0.2	0.3	0.1
			SAMPLE NO. 50			
Croll	2.0	2.4	2.0	....	....	....
Pickard	3.5	2.9	1.1	1.2	1.0	0.5
Steele	3.5	2.4	0.8	0.6	....	....
Mills	2.0	2.4	0.6	0.6	0.6	0.2
Sutherland	2.8	....	....	0.8	....	....
Booge	1.6	2.4	0.3	0.5	0.8	0.5
Bonney	2.6	2.6	1.1	....	....	....
Average	2.57	2.52	0.98	0.74	0.80	0.40
Maximum	3.5	2.9	2.	1.2	1.	0.5
Minimum	1.6	2.4	0.3	0.5	0.6	0.2
			SAMPLE NO. 51			
Croll	1.6	1.2	1.2	....	....	....
Pickard	0.9	1.3	0.1	0.5	0.4	Trace
Steele	1.2	1.2	0.2	0.4	....	....
Mills	1.0	1.2	Trace	0.3	0.3	Trace
Sutherland	1.5	....	....	0.4	....	....
Booge	0.7	1.0	Trace	0.1	0.3	0.3
Bonney	0.8	0.8	0.4	....	....	Trace
Average	1.10	1.13	0.48	0.34	0.43	Trace
Maximum	1.6	1.3	1.2	0.5	0.4	....
Minimum	0.7	0.8	0.1	0.1	0.3	....

TABLE I.—RESULTS OF TESTS ON DETERMINATION OF FOOTS IN LINSEED OIL.—*Continued.*

Observer	Method of Test					
	A.S.T.M. Natural	A.S.T.M. Chilled	A.S.T.M. Chilled Heated	Sutherland Natural	Sutherland Chilled	Sutherland Chilled Heated
SAMPLE NO. 52						
Croll	2.0	2.0	2.0	....	....	....
Pickard	2.6	2.6	1.3	1.6	0.8	0.8
Steele	....	....	....	....	....	....
Mills	1.6	1.8	0.6	0.4	0.5	0.2
Sutherland	2.5	....	....	0.9	....	....
Booge	1.6	2.0	0.4	0.5	0.7	0.5
Bonney	2.8	2.7	1.2	....	....	....
Average	2.18	2.22	1.10	0.85	0.66	0.50
Maximum	2.8	2.7	2.0	1.6	0.8	0.8
Minimum	1.6	1.8	0.4	0.4	0.5	0.2
SAMPLE MO. 53						
Croll	2.0	2.0	1.6	....	....	....
Pickard	0.8	3.4	1.3	0.3	1.2	0.7
Steele	2.2	1.8	0.4	0.5	....	....
Mills	1.6	1.8	0.6	0.4	0.5	0.1
Sutherland	0.7	....	....	0.4	....	....
Booge	1.1	1.0	0.3	0.4	0.5	0.2
Bonney	1.8	2.2	1.2	....	....	....
Average	1.46	2.03	0.90	0.40	0.73	0.33
Maximum	2.2	3.4	1.6	0.5	1.2	0.07
Minimum	0.7	1.0	0.3	0.3	0.5	0.1
SAMPLE NO. 54						
Croll	1.6	2.0	1.6	....	....	....
Pickard	2.3	2.0	1.6	1.3	1.4	1.0
Steele	2.2	2.1	1.4	0.7	....	....
Mills	2.4	2.8	1.0	0.6	0.6	0.3
Sutherland	1.5	....	....	0.7	....	....
Booge	1.6	2.0	1.0	0.5	0.6	0.6
Bonney	....	....	....	....	....	....
Average	1.94	2.18	1.32	0.76	0.87	0.63
Maximum	2.4	2.8	1.6	1.3	1.4	1.0
Minimum	1.5	2.	1.0	0.5	0.6	0.3
SAMPLE NO. 55						
Croll	2.0	2.0	1.6	....	....	....
Pickard	1.2	2.5	1.0	0.6	1.6	0.3
Steele	2.0	1.8	1.0	0.6	....	....
Mills	2.0	2.4	0.6	0.6	0.6	0.2
Sutherland	0.5	....	....	0.5	....	....
Booge	1.6	2.0	0.6	0.5	0.5	0.3
Bonney	2.8	3.1	2.0	....	....	....
Average	1.93	2.30	1.13	0.56	0.90	0.27
Maximum	2.8	2.5	2.	0.6	1.6	0.3
Minimum	0.5	1.8	0.6	0.5	0.5	0.2

for with it applied those materials properly classed as foots are found and measured.

In order to determine the accuracy of the method as applied, the difference between the maximum and minimum results of each set was divided by the average. The quotient, recorded in Table II, approximates the percentage error of the determination.

There is but one conclusion that can be drawn from the data of Table II, and that is that in all modifications and upon all types of oil the test is very inaccurate. The average error varies from 55 per cent to 130 per cent when the results of the determinations by the several modifications of the method are considered. This is shown in the last column of Table II. The average percentage variation limits of all the methods applied to each oil are 141 per cent and 61 per cent error.

Averaging the percentage error on the three samples, each, of old oil, footy oil and fresh oil, the percentage errors are 85.5 for old oil; 91.6 for footy oil and 85.6 for fresh oil.

From these data, therefore, we see that from whatever angle we judge this foots test we find it inaccurate. The chilling and heating results show the greatest percentage variation. This may be due to the manner of heating the oil. The directions called merely for heating to 65.5° C., but did not mention the rate nor the time this temperature should be maintained. We are of the opinion that if the procedure were such that the oil was heated gradually and held at the maximum temperature for an hour with constant or intermittent stirrings that the results might be more concordant.

TABLE II.—PERCENTAGE ERROR OF DETERMINATIONS

	Percentage Error = $\frac{\text{Maximum}-\text{Minimum}}{\text{Average}}$									
	Sample No. 47	Sample No. 48	Sample No. 49	Sample No. 50	Sample No. 51	Sample No. 52	Sample No. 53	Sample No. 54	Sample No. 55	Average Percentage Variation
A.S.T.M. Natural	110	56	100	74	82	55	103	46	119	82.8
A.S.T.M. Chilled	82	70	53	20	44	41	118	37	30	55.1
A.S.T.M. Chilled and Heated	183	49	75	173	230	145	145	45	124	130.0
Sutherland Natural	50	48	160	95	118	266	50	105	18	101.0
Sutherland Chilled	42	64	80	50	23	75	96	92	122	71.6
Sutherland Chilled and Heated	0	77	135	75	0	261	70	111	37	85.2
Average	77	61	101	81	83	141	97	73	75	....

The Sutherland test is shown to offer no advantage over the A.S.T.M. test when applied to the natural, chilled, or chilled and heated oils. The only point of advantage that this method seems to have over the other is that of time, for a determination can be more quickly made. Therefore, the sub-committee concludes that the A.S.T.M. and the Sutherland modification of the A.S.T.M. foots test are both incapable of yielding accurate results in the hands of skilled operators. Consequently, it is recommended that this test be not advanced to standard at this time. The sub-committee will continue work on the subject and will welcome suggestions as to modification of this test or ideas which might lead to the development of tests perhaps fundamentally different but which might give accurate results.

Respectfully submitted on behalf of the sub-committee,

GLENN H. PICKARD,
Chairman.

REPORT OF SUB-COMMITTEE VI ON DEFINITIONS OF TERMS USED IN PAINT SPECIFICATIONS

In response to a request from Mr. E. J. Cole, chairman of Sub-Committee IX on Varnish, the following definitions of the terms "toughness" and "elasticity" were prepared by the sub-committee and are submitted with the recommendation that they be published as tentative revisions of the Standard Definitions of Terms Relating to Paint Specifications (D 16 – 22).[1]

Toughness.—Relative degree of resistance to impact without fracture; opposed to brittleness.

Elasticity of Paint and Varnish Films.—That property which allows a paint or varnish film to follow, without rupture, changes in the extent and form of the surface to which it is applied.

Respectfully submitted on behalf of the sub-committee,

L. P. Nemzek,
Chairman.

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[1] A.S.T.M. Standards Adopted in 1922.

REPORT OF SUB-COMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS

The sub-committee recommends that the Tentative Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments, and Chrome Green (D 126 – 22 T),[1] be revised as follows:

Section 36.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"[Dissolve 1 g. of the sample in 100 cc. of mixture consisting of 125 cc. of 80-per-cent acetic acid, 95 cc. of NH_4OH (sp. gr. 0.90) and 100 cc. of water. Add the solution while hot and dilute with 50 cc. of water, boil until all is dissolved except carbon.] *Digest 1 g. of the sample with 15 cc. of concentrated HNO_3 in a covered beaker. Boil the solution until the brown fumes of the oxides of nitrogen have disappeared. Add 6 cc. of concentrated H_2SO_4 and again boil until the heavy fumes of SO_3 are evolved. Allow the solution to cool, add 30 cc. of water and boil. Remove the beaker from the hot plate and allow the solution to stand for from 3 to 4 hours. Filter the solution, washing the precipitate by decantation 3 or 4 times and allowing the bulk of the precipitate to remain in the beaker. Place this beaker containing the residual lead sulfate under the funnel used for the filtration, wash the filter paper with 75 cc. of a mixture consisting of 95 cc. of NH_4OH (sp. gr. 0.90), 125 cc. of 80-per-cent acetic acid and 100 cc. of water. Follow this washing with 75 cc. of hot water. Boil until the $PbSO_4$ is dissolved.* Dilute to 200 cc. *with hot water, boil* and titrate with standard ammonium molybdate solution, using a freshly prepared solution of one part of tannic acid in 300 parts of water as an outside indicator. Run a blank and correct for same. The ammonium molybdate solution contains 8.67 g. [per] *in one* liter *of water* and is standardized against pure lead foil, pure PbO, or pure $PbSO_4$."

Section 39.—Change the second sentence to read as follows by the addition of the italicized words:

"To the filtrate add 3 cc. of bromine water, heat gently to oxidize the sulfite to sulfate, *acidify with HCl,* and precipitate with $BaCl_2$ solution."

The sub-committee recommends that the tentative methods, as revised, be adopted to standard.

The Gardner method is submitted, as appended hereto,[2] as a proposed Tentative Method of Test for Specific Gravity of Pigments, with the recommendation that it be accepted for publication as tentative. This method was originally published in *Circulars Nos. 104* and *148*, Educational Bureau, Paint Manufacturers' Association of the U. S.

Respectfully submitted on behalf of the sub-committee,

F. W. Smither,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 754 (1922).

[2] See p. 651.—Ed.

REPORT OF SUB-COMMITTEE IX ON VARNISH

During the past year, Sub-Committee IX completed the work outlined in its report for 1922. In that report were included Methods of Testing Varnishes Proposed for Investigation by Sub-Committee IX, which were sent out together with four samples of varnish to 21 sub-committee members who had reported that they could undertake the work of investigation. The suggested methods included methods for appearance, color, non-volatile matter, drying time, water resistance, hot water test, "Kauri" reduction test for elasticity or toughness, and a test for durability by exposure. A number of reports on the results of this investigation are published in the report of the sub-committee for 1922.[1] Reports by H. P. Taber and W. T. Pearce were received too late to be included in last year's report, but they are in excellent agreement with the results of the other observers.

The results of the investigation indicate that the following tests give excellent results in the hands of different operators:

1. Appearance in respect to clarity;
2. Color using secondary standards; and
3. Test for non-volatile matter by weight, using pan method.

With proper care to details, with a proper oven and a little experience excellent results can be obtained with the "Kauri" reduction test. The usefulness of the "Kauri" reduction test as an accelerated method of determining the durability of the varnish depends upon the extent to which it measures those properties of the varnish upon which the durability of a varnish depends.

The following tests will require further investigation:

1. Drying time (some methods of eliminating the personal factor and more sharply defining the terms "Dry to touch" and "Dry hard and tough" are necessary).

2. Water test (a logical interpretation of the results of this test is necessary before its usefulness is understood).

The four varnishes transmitted to the observers were composed as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 375 (1922).

Varnish A.—27½ gal. of tung oil to 100 lb. of ester gum, reduced with a mixture of one half spirits of turpentine and one half mineral spirits.

Varnish B.—125 lb. of Kauri gum, melted until 20 per cent had been driven off and then combined with 27½ gal. of linseed oil and reduced with one half spirits of turpentine and one half mineral spirits, thus producing a varnish having the same gum and oil ratio as Varnish A.

Varnish C.—100 lb. of lime-treated rosin, combined with 27 gal. of linseed oil, reduced with mineral spirits.

Varnish D.—100 lb. of lime-treated rosin combined with 27 gal. of tung oil, reduced with mineral spirits.

Sufficient amounts of various dryers were used in the different varnishes to make the product dry the same as it would be expected to dry in commercial practice.

The exposure test consisted in coating panels of maple wood 4 by 12 by ½ in. with three coats of varnish and coating tin plate with two coats of varnish and exposing these out-doors 45 deg. to the vertical facing south. The observers were requested that in reporting the results of the test the comparative durability on wood and on tin panels be reported and any remarks as to which method was considered better. The results of the exposure tests and the ratings of the four varnishes are given in Table I, appearing in the Appendix to this report together with comments by the observers.

The reports of the various members are in good agreement. Of the fourteen reports submitted, nine rate the varnishes in the exact order that would agree with the results of the Kauri reduction test. In the other five reports, the rating differs from the nine in that one varnish is placed in a different position, but in practically every one of the five this difference in position is for a different varnish.

Eight of the reports give the time of first cracks and in this respect five are in perfect agreement and rate the varnishes in the order of Kauri reduction. In a sixth, the time of first cracks is almost the same for all four varnishes and in two other reports the rating of the varnishes differs but slightly from the order of Kauri reduction and differ from each other.

The results of the exposure tests, although in good agreement, indicate that more accurate methods of investigation of panels are necessary. The following procedure is suggested for the investigation of exposure tests in future work:

1. If the conditions in which the exposure test is being made are such that the panels become dirty, all or part of them should be thor-

oughly cleaned by washing with water before inspection. Otherwise the dirt will obscure small cracks. These small cracks are sometimes the only ones which form and indicate that the varnish is beginning to fail.

2. Panels should be inspected with the use of a magnifying glass having a magnification of from twenty to fifty diameters. Cracks will then be visible which would not be seen by the naked eye of every operator.

3. If cracking is suspected and is not readily seen, the spot should be rubbed with dry lampblack and if the varnish has cracked, the cracks will be filled and readily distinguished.

Various members indicate that they prefer wooden panels to the tin panels because of the greater ease with which the results can be distinguished. If, however, the above plan of filling in the cracks with lampblack is followed, tin panels will give excellent results.

The sub-committee recommends for publication as tentative the proposed Tentative Methods of Testing Oleo-Resinous Varnishes appended hereto.[1] These include tests for appearance, color, non-volatile matter, and the Kauri reduction test for elasticity or toughness. There is some difference of opinion as to the exact property determined by the last named test, that is, whether toughness or elasticity, and until some agreement is reached both terms will be employed.

The three tests, appearance, color, and test for non-volatile matter are in exactly the same form as published in the report for 1922. The Kauri reduction test has been modified somewhat, since it has been found that the relative humidity of the air in which the baked varnish panels are cooled before they are bent can have an appreciable effect on the cracking of the varnish films. The length of this period has, therefore, been decreased from one hour to fifteen minutes, thus reducing the effect of the relative humidity to a minimum.

The results of the investigation mentioned above demonstrate that the Kauri reduction test is a good indicator of the relative durability of varnishes and as a test is more accurate than an exposure test itself. It is not to be assumed that this test is being recommended merely on the basis of the investigation involving only four varnishes that are mentioned in the present investigation. A number of observers have carried out extensive tests on a number of varnishes, comparing the Kauri reduction values with the durability of the varnish. Particular attention is called to the table showing the results on 70 varnishes that appears as a part of the comments by E. A. Stoppel. As mentioned in these comments, the Kauri test can be made quickly, checked if necessary, and run under fairly uniform conditions, whereas in an exposure test there are many variables beyond control.

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[1] See p. 655.—ED.

Three papers on varnish that have been prepared in connection with the work of the sub-committee are appended to this report:

"Accelerated Elasticity Test for Oleo-Resinous Varnishes (The Kauri Reduction Test)," by L. V. Pulsifer.

"Measurement of the Thickness of Varnish Films," by E. A. Stoppel.

"Physical Properties of Varnish Films Indicated by Stress-Strain Measurements," by H. A. Nelson.

Respectfully submitted on behalf of the sub-committee,

E. J. COLE,
Chairman.

APPENDIX

RESULTS OF EXPOSURE TESTS ON VARNISHES

As a result of the exposure test on four varnishes, mentioned in the report of the sub-committee, the varnishes have been rated by the several observers as set forth in Table I. In addition to the remarks given in the table, several of the observers have commented as follows:

COMMENTS BY F. G. BREYER

Panels similar to those used above were exposed to an accelerated aging process of alternate 24-hour exposures to ultra-violet radiations and a water spray.[1] The results of this exposure may be briefly summarized as follows:

Varnish A.—No checking or cracking after 50-days' exposure. At 28 days the surface showed a slight dulling. After 50 days it ranked first in retention of gloss.

Varnish B.—No perceptible checking or cracking after 50 days' exposure. At 25 days slight dulling of surface appeared. Finally slightly inferior to A in gloss.

Varnish C.—Visibly affected by moisture from the beginning. At 3 days, gloss was slightly affected and at 10 days the surface was permanently dulled.

Large checks (alligatoring) began to appear at 6 days. These developed until at 50 days the entire surface was integrated. This varnish gave results indicating that for the type of exposure it was inferior to any.

Varnish D.—Began to show slight checking at 8 days. This checking did not develop rapidly and at 50 days the condition of the surface was superior to C.

Noticeable loss of gloss developed at 20 days. At 50 days the surface was quite dull but superior to C.

Remarks: The general order of merit according to this test would be A, B, D, and C.

The preliminary examination of Varnish C indicates the generally severe effect of moisture on this varnish. Hence, we must recognize that a variation of the exposure cycle, using more light and less water, might enable this varnish to make a better showing, perhaps modifying, or even reversing, the order of apparent relative merit.

It is significant that the results of the accelerated exposures and the outdoor exposures check as closely as they do, when we consider that, due to the rainy season, the proportions of rainy days were roughly the same for each test. Also, neither of the tests was exposed to freezing temperatures. Introduction of freezing temperatures would undoubtedly modify the results, depending on the properties of the varnishes.

COMMENTS BY E. J. COLE

The fact that the cracks were all small suggested the use of microscopic analysis and micro-photograph as a means of studying exposure tests.

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[1] H. A. Nelson, "Accelerated Weathering of Paints on Wood and Metal Surfaces," *Proceedings*, Am. Soc. Test. Mats., Vol. 22, Part II, p. 485 (1922).

The following report and the micro-photographs reproduced in Fig. 1 were obtained by the kind cooperation of Mr. Roy M. Allen, Microscopic Expert, of the Western Electric Co., Past-President of the New York Microscopical Society:

Varnish A.—A large proportion of the total fields examined (at a magnification of approximately 40 diameters) showed an entire absence of cracks, while some showed one or two and others had several, more or less scattered. A frequent condition, however, was a small cluster of cracks, obviously related to each other in some manner, as the surrounding area might be entirely free from them. (The explanation of these clusters may lie in a lack of homogeneity in the varnish or in external exposure conditions, for example, drops of water might remain on the surface after a rain, and followed by strong sunlight, they would act as condensing lenses, concentrating an excess of heat and light on the surface beneath them.)

Because of these different appearances this sample was the most difficult of the lot from which to select a typical field to photograph, but a view showing a cluster and a few isolated cracks was finally chosen.

Very few of the cracks were long and in general they had not started to open up (*i. e.*, the side walls of the cracks to separate from each other). In appearance they are analogous to cracks in glass, extending more or less vertically through the varnish layer from bottom to the top. It is possible that, once formed, they open and close to a certain extent with changes in temperatures and humidity.

Apart from cracks, the surface of the varnish appears very lustrous, but it cannot be stated positively that no change has occurred on it, as a perfectly fresh sample was not available for comparison.

Varnish B.—This sample showed uniform cracking over the entire surface and practically any field chosen might be considered typical of the whole. In general, the length and width of the cracks were of the same order of magnitude as those in Varnish A, but their number was many times greater and a few of the longer ones had started to open up.

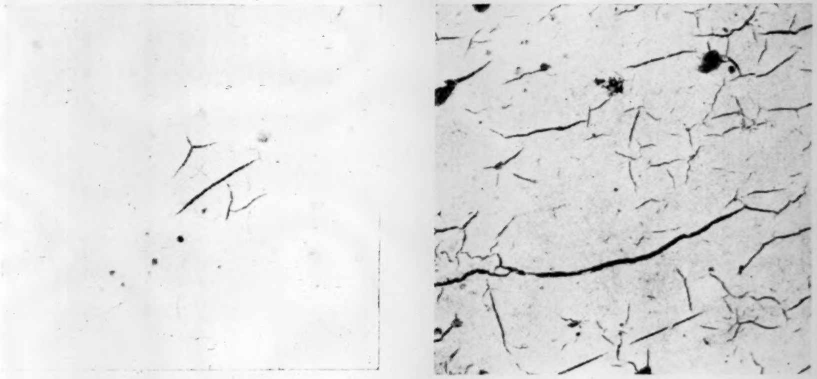
The surface of B did not reflect light quite as well as that of A, as evidenced by a falling off of the illumination near the edges of the micrograph and slightly darker background in general, thus indicating that there is a deterioration of the surface, in addition to the cracking.

Varnish C.—This specimen revealed a great increase in the number of cracks, which are easily separated into at least two generations: an older, consisting of those which are opening up to such an extent that they are "V" shaped (wide at the top and closing toward the bottom), and a younger, in which they still appear as fine hair lines.

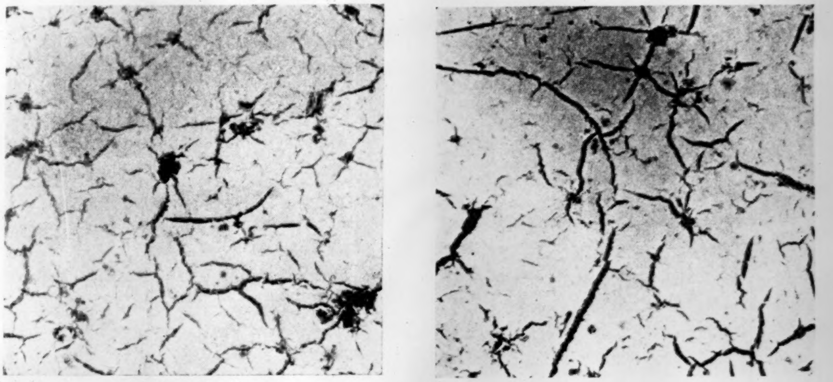
In this sample nearly all the cracks are short and irregular, intersecting each other at all possible angles, and a new condition but vaguely suspicioned in B is now very conspicuous. This is the beginning of complete disintegration of the varnish at certain centers, mostly at the intersection of two or more cracks. Particles of the varnish have fallen out, leaving craters with jagged edges, but the depth of the craters is, in general, less than the depth of the varnish film. A further increase in the surface deterioration is also apparent.

Varnish D.—Varnish D differs from C in that the cracks are much longer and wider and the surface shows still further loss of luster. As in C, there are both old and new cracks, but the former are not so numerous and there is an appearance of regularity about them that is lacking in C. Frequent fields were observed where they intersected at approximately right angles, producing a checkered effect.

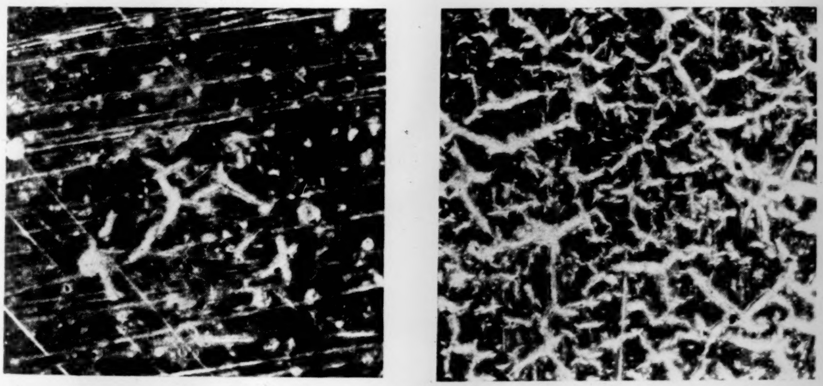
The centers of deterioration were not as noticeable as in C.



(a) Varnish A exposed on wood panel 89 days (b) Varnish B exposed on wood panel 89 days



(c) Varnish C exposed on wood panel 89 days (d) Varnish D exposed on wood panel 89 days



(e) Varnish A exposed on tin panel 89 days (f) Varnish D exposed on tin panel 89 days

FIG. 1.—Photo-Micrographs of Varnish Films in Exposure Tests

TABLE I.—RESULTS OF EXPOSURE TESTS ON VARNISHES

Operator	Panels Exposed		Varnish	Metal Panels		Wood Panels		Remarks
	Place	Time		Time of First Crack	Rating on General Appearance	Time of First Crack	Rating on General Appearance	
F. G. Breyer.....	Palmerton, Pa........	April 10, 1922...	A	56 days	....	Missed	5 mo. No. 1	Of the approximately 150 days' total exposure, 60 days were rainy to the extent that more or less moisture fell during some part of the day; 40 days were cloudy or highly humid. *Wood Panels.*—These panels were not washed at any time during the exposure period. The differences between Varnishes B, C and D were less than the difference between the best of these, Varnish B, and Varnish A.
			B	42 "	....	"	" No. 2	
			C	28 "	....	"	" No. 3	
			D	28 "	....	"	" No. 4	
E. J. Cole........	Brooklyn, N. Y.....	July 5, 1922...	A	Missed	89 days No. 1	Missed	89 days No. 1	Panels were not washed.
			B	"	" No. 2	"	" No. 2	
			C	"	" No. 3	"	" No. 3	
			D	"	" No. 4	"	" No. 4	
E. C. Holton.....	Cleveland, O........	March 30, 1922...	A	Missed	271 days No. 2	Missed	271 days No. 2	The varnished panels examined after 86 days were found to be in good condition. The panels were exposed on a very dirty roof close to a railroad in the heart of the manufacturing district, and it was necessary to wash them with a sponge and water at about 90° F. at the time of the final examination. For about ten days during December, they were buried in a snow drift.
			B	"	" No. 1	"	" No. 1	
			C	"	" No. 3	"	" No. 3	
			D	"	" No. 4	"	" No. 4	
F. P. Ingalls.....	Brooklyn, N. Y	January 29, 1922	A	......	....	43 days	113 days No. 2	After one year, all varnish had fallen off Panels A, C and D, but on Panel B, although the varnish is badly cracked, it still adhered to the wood.
			B	......	....	45 "	" No. 4	
			C	......	....	45 "	" No 1	
			D	......	....	45 "	" No 3	
R. W. Lindsay...	Buffalo, N. Y.....		A	......	No. 1	......	No. 1	
			B	......	No. 2	......	No. 2	
			C	......	No. 3	......	No. 2	
			D	......	No. 4	......	No. 4	
W. T. Pearce....	Agricultural College, N. D.....	May 15, 1922...	A	......	....	123 days	123 days No. 1	Inspection was made each week at the same time. A 4-in. magnifying glass which has a 10-in. focus was used. We did not wash the panels but gave them a thorough rubbing with waste before inspecting them. We noted the first signs of checking, roughness, whitening, cracking and loss of luster. We did not consider that a varnish had failed until it had lost all of its luster and the film was completely cracked.
			B	......	....	76 "	" No. 2	
			C	......	....	61 "	" No. 3	
			D	......	....	61 "	" No. 4	
A. H. Sabin...... (R. L. Hallett)	Brooklyn, N. Y.....	March 6, 1922....	A B C D					After an exposure of about sixteen weeks, the varnish on both the tin and the wooden panels showed no visible cracks; the gloss was almost completely gone; the varnish films had taken on a deeper yellow color; and the surface of the varnishes was rather badly spotted; the spotting being more pronounced on the tin panels than on the wooden ones. After an exposure of about 20 weeks of the wood panels, Panel A showed definite cracks, with Panels C and D beginning to show them. About 6 weeks later, Panel B first showed cracks, while the other panels were becoming heavily weather marked, that is, they had lost all luster and had become dark in color. Nine weeks later, the varnish on Panels A, C and D was completely cracked and falling off. Panel B showed the same condition to a less extent. The tin plates do not show any definitely formed cracks in the varnish, though they have the appearance of the varnish being completely worn off.

Operator	Panels Exposed		Varnish	Metal Panels		Wood Panels		Remarks
	Place	Time		Time of First Crack	Rating on General Appearance	Time of First Crack	Rating on General Appearance	
J. M. Sanderson. .	Buffalo, N. Y.	January 23, 1922	A	. . . . . .	150 days No. 1	. . . . . .	150 days No. 1	The exposure tests were made at the factory where the atmosphere is very dirty. Samples became covered very quickly with cinders and grease which made examination difficult without thorough washing and each washing undoubtedly hastened destruction. For weathering tests wood panels are favored, as the film generally goes to pieces quicker and is also more readily observed owing to the blackening of the wood beneath.
			B	. . . . . .	" No. 2	. . . . . .	" No. 2	
			C	. . . . . .	" No. 3	. . . . . .	" No. 3	
			D	. . . . . .	" No. 4	. . . . . .	" No. 4	
C. L Sargent. . . .	Newark, N. J.	March 12, 1922. . .	A	75 days	99 days No. 1	75 days	99 days No. 1	
			B	75 "	No. 1	75 "	" No. 2	
			C	99 "	" No. 2	. . . . . .	" No. 4	
			D	82 "	" No. 3	89 "	" No. 3	
L. L. Steele.	Washington, D. C.	February 6, 1922.	A	119 days	137 days No. 1	None at 137 days	137 days No. 1	We have never found it necessary to wash the panels before inspection. We use a small magnifying glass in examinging the panels. but we do not report any checks or cracks which are not visible to the naked eye, after they are located with the glass. We have found that when the sun is at our back we can see the signs of deterioration on the panels more rapidly.
			B	112 "	" No. 2	137 "	" No. 2	
			C	85 "	" No. 3	85 "	" No 3	
			D	73 "	" No. 4	73 "	" No. 4	
E. A. Stoppel. . . .	Brooklyn, N. Y.	August 22, 1922. . .	A	. . . . . .	. . . .	116 days	116 days No. 1	After 76 days cracks appeared on Varnish B, but these had evidently resulted from slight scratches during washing. Definite stars, characteristic of weather exposure, did not appear until 106 days. The question arises as to which is the proper time of failure. Undoubtedly if the panels had not been washed the failure date on B would have been intermediate.
			B	. . . . . .	. . . .	78–106 "	" No. 2	
			C	. . . . . .	. . . .	72 days	" No. 3	
			D	. . . . . .	. . . .	64 "	" No. 4	
J. B. Young.	Reading, Pa.		A	. . . . . .	365 days No. 1	. . . . . .	365 days No. 1	These panels have been exposed to the elements for one year and we find that the varnish has disappeared from the wood panels with the exception of a portion of the panel painted with Varnish A. On the tin panels all the varnishes are still intact, some, however, being in better condition than others.
			B	. . . . . .	" No. 3	. . . . . .	" No. 3	
			C	. . . . . .	" No. 4	. . . . . .	" No. 4	
			D	. . . . . .	" No. 2	. . . . . .	" No. 2	
E. E. Ware.	Detroit, Mich.		A	105 days	105 days No. 1	105 days	105 days No. 1	It was very difficult to judge accurately the varnish films on the tin plate panels. However, so far as could be determined, the first cracks appeared at approximately the same time as those on the wooden panels. The wooden panel method is by far the better procedure for making weather exposure tests.
			B	91 "	" No. 3	91 "	" No. 3	
			C	98 "	" No. 2	98 "	" No. 2	
			D	98 "	" No. 2	98 "	" No. 2	
F. A. Wertz.	Pottstown, Pa.	April 24, 1922. . .	A	106 days	106 days No. 1	106 days	106 days No. 1	The panel rack was located within twenty-five feet of the main line of a railroad. In this location so much dirt and soot was deposited on the panels, that it was almost impossible to tell accurately just when the first cracks appeared on the films. If local areas of the films are washed, these areas develop cracks earlier than the unwashed areas. Perhaps this is due to the protective action of the dirt film. The results of the exposure tests indicated that the length of life of the varnish is in the same order as indicated by the Kauri Reduction tests, but the relative life of Varnish A, for example, compared to that of Varnish D, is considerably shorter than would have been expected when judging the results obtained on these two varnishes by the Kauri Reduction test.
			B	87 "	" No. 2	87 "	" No. 2	
			C	68 "	" No. 3	68 "	" No. 3	
			D	59 "	" No. 4	59 "	" No. 4	

Method of Photo-micrographing.—The photo-micrographs were taken at a magnification of approximately 37 diameters. Two methods were tried out with success: one using the reflected and refracted light thrown out by the cracks themselves, the exposure being timed so that the background appeared black; in the other, the crack were made visible by infiltrating with carbon ink (Higgins) and exposing so that the background appeared light.

As the latter method yielded photographs susceptible of easier interpretation, it was used on the entire set of wood samples, while samples A and D on the tin plate were taken by the other method for comparison. (Note.—In sample A on the tin plate it is necessary to disregard the numerous parallel lines which are scratches on the surface of the tin.)

The illumination in both cases was obtained by means of the Silverman illuminator.

COMMENTS BY E. A. STOPPEL

I have noted there is considerable difference of opinion among various operators as to what constitutes first signs of perishing. Some take the very first crack or check; others, when the checks become general; some, disappearance of gloss; and others, the showing of wood. During the war I had occasion to examine many panels of varnishes submitted for airplane use and found the best end point was at the time that the *first definite signs of checking or cracking appeared.* The naked eye was not depended on for determining this point but a glass, magnifying 5 or 10 diameters, was used as an aid. Frequently varnishes were found which became dull but showed no cracks visible to the naked eye but under the glass numerous very fine cracks became visible and explained why the gloss was disappearing. It was found impossible to judge panels accurately out-doors on cloudy days. Clear, or preferably hazy days are best and in examining panels the sun must be reflected from the varnished surface up to the eye of the observer or up through the glass if such is being used. The light in this way is so blinding that the observer should wear amber glasses for protecting the eyes. If the light is reflected at the proper angle, with a little practice one can detect checks or cracks on most varnishes without a magnifying glass. Only occasionally, on varnishes that tend to form very fine cracks, is it necessary to use a glass for detecting signs of perishing. This condition is frequently found after the first stages of perishing have passed. Varnishes were often found on which checks were plainly visible on one date but when examined a week or two later the checks were so numerous and close together that the panel had only a dull appearance. It was not until a magnifying glass was used that any cracks could be seen at all.

A few isolated checks on panels were not considered definite signs of perishing as these checks may be due to various causes, but such panels were watched closely on future inspection. If checks were no worse on the next inspection date the panel was considered O.K. When the first definite signs of perishing appear there will be small stars, forks or cracks distributed uniformly over the entire panel so that perishing is unmistakable. Varnish B was a good example of such a condition. On the first exposure test this varnish developed a few isolated stars before any of the other three varnishes. If judged by first cracks this varnish would have been judged least durable of the four, but by the above method it would have been considered second or third best. On the subsequent exposure test this varnish was unquestionably second best, the same position it was placed in by the Kauri test.

Another point which must be considered in making exposure tests is the washing of panels during the test. Some varnishes stand abrasion much better than others.

If panels are washed, even though the washing is done ever so carefully, the varnish is sure to be abraded more or less. Any abrasion, even though not visible at the time, develops into a crack and on some types of varnishes this abrasion has a much more serious effect than on others. This was noted in the set of varnishes distributed. Varnishes A, C, and D showed the normal check and zigzag cracks even though the panels had been washed. The first cracks on B, on the contrary, were straight or curved lines, indicating plainly that they had developed from scratches during the washing. It is perfectly clear that if varnishes of this type are washed occasionally and the surface abraded more or less we will get varying exposure data that will lead us nowhere. I believe that if we wish to obtain concordant results and exposure data which mean anything, panels should not be washed. If necessary, only such portion should be washed as is necessary for examination and that portion be disregarded on future inspection.

In regard to the Kauri test, the U. S. Bureau of Standards and Bureau of Aircraft Production, during the war, used this as one of the tests for determining the suitability of varnishes for airplane use. Some of the comparisons of Kauri and exposure tests made at that time may be of interest. The specifications stated that the varnish must be equal to standard in durability. Until the durability test was completed any varnish passing 50-per-cent reduction on the Kauri test could be accepted at once and assumed to be sufficiently durable. Two different varnishes were used as standards. These were varnishes that stood approximately 60-per-cent reduction. Any varnish on which the durability was at least 80 per cent as long as the standard was considered satisfactory. The first important fact to be noted is that out of 149 varnishes tested, 80 passed 50-per-cent reduction, and of these 80 not one was found inferior on the exposure test. This is remarkable, as it is conceded that elasticity is only one factor, but the most important, on which durability depends. It did not follow, however, that all varnishes that passed the exposure test had passed the 50-per-cent reduction on the Kauri test. This is hardly to be expected even if the test were perfect. For instance, a varnish might be considerably inferior to the standard and stand exposure, under normal conditions, to a point where it was about to check if conditions continued. If at this point weather prevailed which was much more severe on varnishes, when examined again it might be found that not only the varnish under the test but also the standard had checked. This is not at all an unusual circumstance. Sets of airplane varnishes, including standards with each set, were exposed at the Bureau of Standards on January 18, February 11, February 21, March 11, March 22, March 30 and April 15, 1918. All of the standards were in perfect condition on June 15. This was followed by a period of cool damp nights and hot sunny days. When the panels were examined on June 22 all of the above standards had developed checks or cracks. Here we have the same two varnishes exposed at seven different intervals, all showing perishing on the same day with a life ranging from 155 to 68 days. Exposure tests under such conditions are certainly unreliable and many varnishes under test and showing first cracks on June 22 are really less durable than the standards. It would follow also that even if the Kauri test was a perfect indicator of durability, many varnishes cracking at 50 per cent or less reduction would appear equally good under the above exposure conditions. Excepting possibly the first set of panels, I believe that the Kauri test would have given a far more accurate indication of durability than the actual exposure test.

It would be impossible to give exposure data on all varnishes tested but in Table II is given a comparison of Kauri and exposure tests on all varnishes exposed at a

TABLE II.—COMPARISON OF KAURI REDUCTION AND EXPOSURE TESTS ON VARNISHES

Varnishes are arranged according to life expressed in terms of percentage of life of standard varnishes exposed at same time. "C." indicates cracked; "V.S.C.," very slightly cracked; "S.C.," slightly cracked; and "B.C.," badly cracked.

Varnish	Life on Exposure			Kauri Test		
	Varnish Under Test, days	Standard Varnish, days	Per Cent of Standard	0 Per Cent Reduction	25 Per Cent Reduction	50 Per Cent Reduction
1	11	103	11	B.C.	B.C.	B.C.
2	22	121	18	B.C.	B.C.	B.C.
3	47	131	36	O.K.	O.K.	C.
4	63	131	48	C.	B.C.	B.C.
5	51	105	49	B.C.	B.C.	B.C.
6	67	121	55	O.K.	B.C.	B.C.
7	61	105	58	S.C.	B.C.	B.C.
8	77	131	59	S.C.	B.C.	B.C.
9	64	105	61	C.	B.C.	B.C.
10	66	103	64	O.K.	S.C.	B.C.
11	70	105	67	B.C.	B.C.	B.C.
12	84	121	69	C.	B.C.	B.C.
13	73	105	69	C.	B.C.	B.C.
14	73	105	69	C.	B.C.	B.C.
15	88	105	84	O.K.	O.K.	O.K.
16	88	105	84	O.K.	O.K.	O.K.
17	88	105	84	O.K.	O.K.	C.
18	88	105	84	O.K.	O.K.	O.K.
19	88	105	84	O.K.	V.S.C.	B.C.
20	88	105	84	O.K.	V.S.C.	B.C.
21	89	105	85	O.K.	O.K.	O.K.
22	89	105	85	O.K.	O.K.	C.
23	89	105	85	S.C.	C.	B.C.
24	92	105	88	O.K.	O.K.	O.K.
25	95	105	90	O.K.	O.K.	C.
26	95	105	90	O.K.	S.C.	B.C.
27	98	105	93	O.K.	O.K.	O.K.
28	98	105	93	O.K.	V.S.C.	B.C.
29	98	105	93	O.K.	O.K.	O.K.
30	98	105	93	O.K.	V.S.C.	C.
31	98	105	93	O.K.	O.K.	O.K.
32	98	105	93	O.K.	O.K.	O.K.
33	98	105	93	O.K.	O.K.	O.K.
34	98	105	93	O.K.	O.K.	C.
35	102	105	97	O.K.	O.K.	O.K.
36	103	105	98	O.K.	O.K.	O.K.
37	102	105	98	O.K.	O.K.	C.
38	103	105	98	O.K.	O.K.	O.K.
39	131	131	100	O.K.	O.K.	O.K.
40	121	121	100	O.K.	O.K.	O.K.
41	131	131	100	O.K.	O.K.	O.K.
42	103	103	100	O.K.	O.K.	O.K.
43	105	105	100	O.K.	O.K.	O.K.
44	107	105	102	O.K.	O.K.	O.K.
45	107	105	102	O.K.	O.K.	O.K.
46	107	105	102	O.K.	O.K.	O.K.
47	110	105	105	O.K.	O.K.	O.K.
48	165	155	106	O.K.	O.K.	O.K.
49	141	131	108	O.K.	O.K.	O.K.
50	113	105	108	O.K.	O.K.	O.K.
51	113	105	108	O.K.	O.K.	O.K.
52	113	105	108	O.K.	O.K.	C.
53	120	105	114	O.K.	O.K.	O.K.
54	120	105	114	O.K.	S.C.	B.C.
55	120	105	114	O.K.	O.K.	O.K.
56	151	131	115	O.K.	O.K.	O.K.
57	122	105	116	O.K.	O.K.	O.K.
58	122	105	116	O.K.	O.K.	O.K.
59	123	103	120	O.K.	O.K.	O.K.
60	128	105	122	O.K.	O.K.	O.K.
61	128	105	122	O.K.	O.K.	O.K.
62	128	105	122	O.K.	O.K.	O.K.
63	128	105	122	O.K.	O.K.	O.K.
64	128	105	122	O.K.	O.K.	O.K.
65	132	105	126	O.K.	O.K.	O.K.
66	135	105	128	O.K.	O.K.	O.K.
67	135	105	128	O.K.	O.K.	O.K.
68	155	105	148	O.K.	O.K.	O.K.
69	155	105	148	O.K.	O.K.	O.K.
70	155	105	148	O.K.	O.K.	O.K.

time when the standard exposed with them lasted 100 days or more. These may be considered fairly reliable.

It will be remembered that the standard varnishes with which exposure comparisons are made stood 60-per-cent reductions; therefore, not all varnishes passing only 50 per cent could be expected to be as durable. It will be noted that the exposure and Kauri test agreed very well. There were only two marked exceptions, Varnishes 3 and 54. The former also differed from the usual run of varnishes in other characteristics. In fact, it appeared more like an oil dryer. The color was as dark as 8 g. of potassium bichromate dissolved in 100 cc. of sulfuric acid. The non-volatile was normal (44 per cent) but the viscosity was very low. The thickness of a coating flowed on glass and measured 3 in. from the upper edge after drying was only 12 microns, compared to about 25 microns for a normal varnish. The ash was 0.38 per cent consisting of cobalt only. This certainly is a freak varnish or else no varnish at all. This leaves only Varnish 54 on which exposure and Kauri tests did not check up reasonably well. If it were possible, it would be interesting to check upon this varnish again to see if the tests had been made correctly as another varnish submitted by the same manufacturer at that time checked up perfectly on these two tests.

Of course it would be impossible to draw conclusions as to the reliability of the Kauri test, as a means of predicting durability, from only the four varnishes tested by the sub-committee, but with the additional experience and information obtained in testing other varnishes, I believe this test, when properly made, is reliable. It certainly is far more dependable than an exposure test itself. It can be made quickly, checked if necessary, and run under fairly uniform conditions, but on the exposure test we have so many variables beyond our control.

APPENDIX

ACCELERATED ELASTICITY TEST FOR OLEO-RESINOUS VARNISHES (THE KAURI REDUCTION TEST)

By L. V. Pulsifer

Elasticity is the most important factor in determining the service durability of a finishing varnish, and, other things being equal, the comparative durability of a series of varnishes will follow exactly their comparative elasticity. This factor may be successfully estimated in the laboratory by use of the so-called Kauri Reduction Test for Elasticity. This test was developed by the writer a number of years ago as the culmination of a long extended and comprehensive series of experiments looking toward the perfection of a laboratory method for rapidly and accurately estimating the elasticity factor in a varnish. This test for elasticity was adopted by the Government during the World War for determining the elasticity of varnishes offered for airplane use, and for eliminating those considered too inelastic for the purpose. It has since appeared in numerous specifications to replace the former slow and unsatisfactory panel exposure test.

The reduction test is based on the fact that, the other elements in a varnish being equal, the elasticity will vary with the gum-oil ratio or, in other words, the higher the fixed oil content in terms of the gum content the greater the elasticity. Therefore, in this test various amounts of a standardized gum in solution in re-distilled spirits of turpentine are added to the varnish under examination. The varnish is subsequently put through a forced drying process on a standardized tin plate and then the plate thus coated with the varnish is bent rapidly over a rod of fixed diameter. The amount of gum solution necessary to bring the varnish to the cracking point under this procedure forms the measure of its original elasticity; that is, the greater the amount of gum solution necessary, the higher is the elasticity factor in the varnish under test. The elasticity factor is read and recorded in terms of the percentage of gum solution it is necessary to add to bring the varnish to the cracking point—say, 20, 60, or 120, as the case may be. This test estimates only the elasticity factor of the varnish and not the original gum-oil ratio, for the type of gums and oils used, the type and amount of dryer and the heat treatment of the varnish during manufacture all influence the elasticity factor of the finished product to a tremendous degree. Thus, it is possible to have two varnishes of the same gum-oil ratio that will show a difference of 100 per cent or more in their factor of elasticity. This fact shows why it is easier to estimate the quality of a varnish by physical tests than by analysis of components even were such analysis possible with any degree of accuracy.

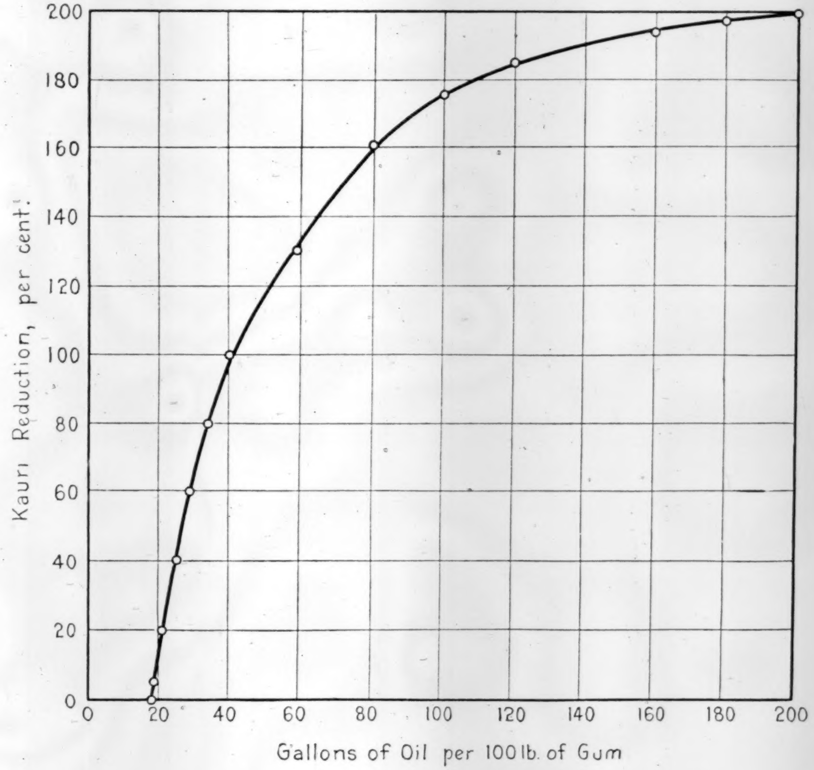


FIG. 1.—Ratio of Oil Content to Kauri Reduction in a Series of Similarly Made Varnishes

The range of the percentages of gum solution that exterior varnishes will stand on this Kauri reduction test is from zero to 200, the zero per cent being on the border line between the most elastic of the rubbing varnishes and the least elastic of the finishing varnishes and the figure of 200 per cent representing the maximum possible elasticity of a fixed vegetable oil varnish containing no gum whatever.

In a series of exterior varnishes properly made from suitable materials, Fig. 1 illustrates the rate at which the amount of Kauri solution increases with the increased oil content of the varnish. It will be seen from the figure that a 20-gal. varnish passes about a 5-per-cent Kauri Reduction, whereas a varnish of which the non-volatile is all oil just fails at 200-per-cent reduction. In such a series, the amount of Kauri solution necessary to bring each varnish to the breaking point is also the amount required to bring the varnish just below 20 gal. of oil to 100 lb. of gum.

To illustrate this, take a 50-gal. varnish which on referring to the chart is seen to break at 100-per-cent Kauri reduction. Calculated on the basis of a full batch, the non-volatile in a 50-gal. varnish will be 390 lb. of oil plus 100 lb. of gum, or 490 lb. This would take an addition of 100 per cent or 490 lb. of Kauri solution which solution would contain 163 lb. of Kauri gum. This addition would make the content of the varnish 390 lb. of oil and 263 lb. of gum which converted would be an 18-gal. varnish. Again, a 100-gal. varnish fails with a 175-per-cent reduction and this calculated as above shows the final mixture to be a 17-gal. varnish. An all-oil varnish to which it is necessary to add 200 per cent of Kauri solution to bring it to the breaking point figures as follows: 100 gal. of oil equals 780 lb. plus 200 per cent or 1560 lb. of Kauri solution, which contains 520 lb. of gum, equals a varnish containing 19 gal. of oil to 100 lb. of gum.

(As stated above in a series of unknown and differently made varnish, the Kauri reduction figure is in no sense a safe estimate of the original gum-oil ratio of each varnish.)

The Kauri test in use in our laboratories for about ten years has proved a very accurate measure of the elasticity factor of varnishes and as the elasticity factor is the most important element in estimating the durability of an exterior varnish the importance and value of this test is apparent. Of course, many other elements affect the service durability of any given varnish and each of these must be accorded proper recognition in making a laboratory estimate of an unknown varnish. Perhaps some of the unsatisfactory results obtained with the Kauri test have been due to trying to translate its results directly into estimated durability without taking into consideration other contributing factors. Other unsatisfactory results have undoubtedly been due to the failure to follow directions carefully, and in a test as delicate as the Kauri reduction test "carefully" means "*exactly*" if accurate results are to be obtained. As an instance of the above, it may be stated that the service durability of a varnish, other factors being equal, varies almost directly with the thickness of the dried film, yet this fact is frequently disregarded when estimates of durability are made.

APPENDIX

MEASUREMENT OF THE THICKNESS OF VARNISH FILMS

By E. A. Stoppel

When the author first began work on varnishes for airplane use at the U. S. Bureau of Standards during the war, it was desired to know the thickness of a coating of varnish. This was desirable as it is an accepted fact that a very thin coating does not give as much protection as a normal one. Some idea of the relative thickness can be obtained from the viscosity and non-volatile determinations but more exact information than could be obtained in this way was desired. From the thickness of film we could not only get an idea of the protection given but could also calculate with a fair degree of accuracy, if desired, the weight added to a plane by a coat of varnish or the number of square feet of surface a gallon of the varnish under test would cover.

The first method that suggested itself was to flow the varnish on a pane of glass and after drying, to measure the thickness of the glass and varnish, and then to remove the varnish and measure the thickness of the glass alone. This was done. After measuring the thickness of the glass plus varnish with delicate measuring instruments, the varnish at the point of measurement was scraped off clean and the thickness of glass measured. We expected this method would give very accurate results, but instead we found that different measurements, all taken within a $\frac{1}{16}$-in. circle varied from 10 to 20 microns, which represented 50 to 100 per cent of the thickness of the film. The method was entirely too inaccurate for the purpose.

Since that time, A. H. Pfund, of Johns Hopkins University, has given us the paint and varnish film gage which yields much better results. This instrument, however, must be used on the wet film. While this gives sufficiently accurate results on paint films containing little or no volatile matter, the measurement of varnish films is not so satisfactory. On varnishes, the film would have to be measured before evaporation of the thinners, and the final thickness calculated from the non-volatile matter, or after the thinners had completely evaporated and before the varnish had set. Mr. Gardner has shown in his paper on "The Evaporation of Thinners from Paint and Varnish Films" that the evaporation of thinners from a varnish film at first is so rapid that it would be impossible to obtain a reading at that time. Therefore, the film would have to be gaged after the thinners had evaporated. We have no accurate indication when thinners have evaporated and in many cases the film has set before the thinners have completely evaporated. A measurement of the completely dried and hardened film would be more satisfactory.

Another method which has been used consists in applying two or three coats of varnish to a sheet of sized paper previously coated with a solution of caramel and allowed to dry. The varnished paper is immersed a few minutes in warm water, which penetrates the paper, dissolving the caramel and permitting the removal of the clear varnish sheet. This film after washing free of caramel and drying can then be measured between the two disks of a paper gage.

This method is perhaps accurate enough for all practical purposes but it must be remembered that since the film is measured between two parallel disks the thickness indicated is the measurement at the thickest part. Anyone having experience in the application of varnishes knows the difficulty of applying in the ordinary laboratory an absolutely clean coat of varnish free from specks.

The method outlined below is a very simple one and can be carried out with the equipment available in most chemical laboratories. It is accomplished by making a scratch or cut on a film of varnish dried on a panel of glass and focusing a high-powered microscope alternately on the upper and lower edge of the varnish. By noting the difference in adjustment of the instrument at the two different settings, the thickness of the film can be calculated.

For this purpose, a microscope capable of a magnification of 400 diameters or over is required. There must also be a scale on the fine-adjustment focusing screw. A movable stage is also desirable but not absolutely essential. A very sharp knife for cutting the varnish film is also necessary. The author has found a steel eraser well sharpened with a slightly rounded point to be most satisfactory. Before the microscope can be used, the value of each division on the fine-adjusting screw must be determined. This can be done in several ways but perhaps the simplest is as follows: Turn the fine adjusting screw down to the right as far as possible. Place upon the stage of the microscope a plate of heavy glass and with the coarse adjustment turn the tube down until the objective just touches the glass. Now turn the fine adjusting screw up or to the left as far as possible, noting the number of complete turns and fractions required. Then measure accurately the distance the objective has been lifted from the glass plate. Dividing this distance by the number of turns of the adjusting screw, gives the pitch of the screw and, dividing by the number of divisions, the value of each division on the scale of the adjusting screw. Microscopes are usually so designed that a turn of one division on the adjusting screw raises or lowers the tube one micron. If this is the case, the thickness of the varnish film is obtained, in microns, by simply subtracting the two readings on the scale.

It is impossible to see when the surface of the varnish or the surface of the glass is in focus unless the film is broken or cut in some way. This is best done with the steel eraser mentioned above. When cutting the film, the glass panel is placed before one, but not too close to the body, the steel eraser, held as one would hold a pencil, is drawn over the varnished surface toward one so that the point cuts through the film clear to the glass. A cross-section of the cut should look similar to Fig. 1. A little practice may be required in cutting the film at the proper slant so that both the upper and lower edge of the cut appear within the field of the microscope. The microscope may then be focussed sharply first on edge *A* and then on edge *B* and the difference in reading of the fine adjustment screw noted. With a little practice, one can obtain readings agreeing within a few microns, especially if the objective is of sufficient magnifying power.

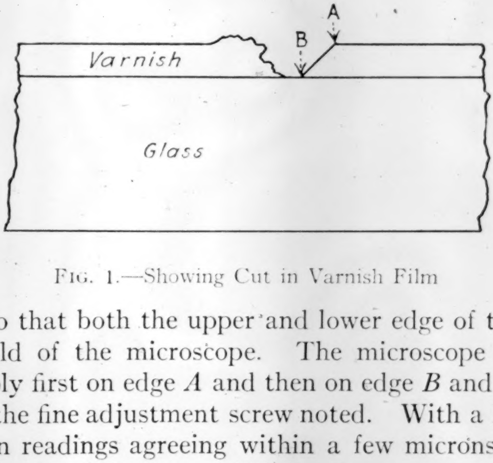


FIG. 1.—Showing Cut in Varnish Film

It has been found by experiment that if varnish is flowed on glass panels and allowed to drain and dry in a nearly vertical position, the thickness of the coating 3 in. from the top of the panel is practically the same as the thickness of a brushed coat applied to a similar surface. Thus if the volume of non-volatile matter in a gallon of varnish is determined, by measuring the thickness of the film we can calculate the number of square feet one gallon will cover. The author has done this in numerous instances and the calculated number agreed within a few per cent with the number determined by actual test.

When the exposure panels in a test of four varnishes carried out by Sub-Committee IX on Varnish, of Committee D-1, were prepared, the amount of varnish applied to the wooden panels was recorded. The sample and brush were first weighed. After varnishing on the top and edges duplicate panels 4 by 8 by ½ in., the remainder of the sample and brush were re-weighed. The difference was taken as the weight of varnish applied to the panels. Multiplying this weight by the non-volatile percentage gives the weight of non-volatile applied. Now if we assume the specific gravity of the non-volatile to be one, which is near enough for the purpose, we can calculate the thickness of the varnish film, as given in the following table:

	WEIGHT OF THREE COATS, G.	WEIGHT OF NON-VOLATILE MATTER, G.	THICKNESS, MICRONS	
			THREE COATS	ONE COAT
Varnish A............	9.4	4.42	80.3	26.8
Varnish B............	9.8	5.15	93.7	31.2
Varnish C............	11.05	5.03	91.4	30.5
Varnish D............	10.9	4.94	89.7	29.9

The same varnishes were also flowed on glass panels 4 by 6 in. in size and allowed to drain and dry in a nearly vertical position.

The films were then measured 3 in. from the upper edge by the microscope method just described. The thicknesses were found to be as follows:

	THICKNESS		THICKNESS
Varnish A..............	23 microns	Varnish C..............	29 microns
Varnish B..............	30 "	Varnish D..............	28 "

These measurements agree very closely with the thickness calculated from the varnish applied. The calculated thickness is slightly higher. This is to be expected as there would be more varnish applied in the first coat due to absorption by the wood.

Mr. E. J. Cole and the author also took measurements of varnish films with the Pfund film gage. The varnishes were flowed on three sets of clean tin panels, 3 by 5 in. in size, and measurements were taken at the top and bottom at three different intervals. Varnishes were flowed at 2.40 P. M. and measurements were taken at 3.45, 4.30 and 5.30 P. M. The following are the results obtained:

		VARNISH A	VARNISH B	VARNISH C	VARNISH D
Thickness at Top	First Reading.....	30 microns	36 microns	56 microns	53 microns
	Second Reading...	27 "	36 "	39 "	42 "
	Third Reading....	25 "	30 "	30 "	(set)
Thickness at Bottom	First Reading.....	49 microns	64 microns	90 microns	90 microns
	Second Reading...	53 "	60 "	81 "	72 "
	Third Reading....	49 "	49 "	60 "	(set)

Since the tins used were only 5 in. long, the average of the readings taken near the top and near the bottom should give a figure quite close to the microscopic method. The figures for the thickness near the top approach that figure but this measurement was taken 1½ in. from the top instead of 3 in. The average reading in no case even approaches the microscopic measurement, nor do the thinners appear to be removed completely even after two hours and fifty minutes. Varnish D had dried to such a degree that it was impossible to obtain a third measurement and, judging by the other varnishes, considerable thinners were still retained at the second measurement. Therefore, it will be seen that quick-drying varnishes cannot be measured with the Pfund film gage at all and in the present case the slower-drying varnishes gave measurements quite different from the microscopic method.

In spite of the fact that the viscosities of these varnishes varied considerably, all gave films varying but little in thickness. Commercial varnishes have been found which give films ranging in thickness from 10 to 38 microns.

APPENDIX

PHYSICAL PROPERTIES OF VARNISH FILMS INDICATED BY STRESS-STRAIN MEASUREMENTS

By H. A. Nelson

While preparing data for a paper presented before the Society in 1921,[1] certain physical differences between varnishes were for the first time studied graphically by their stress-strain diagrams. In Fig. 1, Curves Nos. 2 and 3 are characteristic of high-grade spar varnishes designed for exterior exposures while Curve No. 4 is typical for a good grade of varnish as generally designed for interior exposures alone.

The differences are quite apparent, the spar varnish being characterized by a high distensibility throughout, an increasingly high tensile strength when allowed to oxidize (Curve No. 3), and rubber-like properties indicated by the final resistance to rupture or "S" type of stress-strain curve. The interior varnish (Curve No. 4) shows a characteristic lower distensibility and the entire absence of any rubber-like resistance to final rupture, the curve being of the so-called "rigid" type. It was also observed that upon oxidation, the curve for a varnish of type No. 4 approached the load axis more rapidly, losing much of its distensibility and becoming increasingly brittle.

Further study of the effects of absorbed moisture on stress-strain curves proved that the curves for varnish films follow the observed general rule for paint films, namely, that the distensibility varies directly, while the tensile strength varies inversely as the absorbed moisture content of the film.

The four varnishes submitted by Sub-Committee IX on Varnish, of Committee D-1, in a cooperative investigation conducted by the sub-committee, offered an opportunity to study the properties of varnishes of known compositions. It was impractical to follow every step of the treatment given the films in the Kauri reduction test, but the conditions outlined for that test were approximated. The films were flowed on amalgamated tin sheets and allowed to dry for four days, or sufficiently long to permit easy handling. Stripping and cutting the test specimens previous to baking were necessary because some of the baked varnishes became entirely too brittle to permit specimens to be cut without causing flaws. The test specimens were then baked for 5 hours at 95 to 100° C. Subsequently several specimens from each varnish were placed in (1) a desiccator over $CaCl_2$, (2) a humidor maintained at 30 per cent relative humidity (over H_2SO_4 and water), (3) a humidor at 60 per cent relative humidity, and (4) a humidor at 80 per cent relative humidity. After allowing 48 hours, to make sure that each specimen attained a state of equilibrium, stress-strain measurements were taken with results as indicated in Figs. 2, 3, 4 and 5. In some cases, due to accidental flaws in the specimens, complete sets of curves were not obtained, and the limited supply of the varnishes on hand at the time prevented repetition of the work.

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[1] H. A. Nelson, "Stress-Strain Measurements on Films of Drying Oils, Paints and Varnishes," *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 1111 (1921).

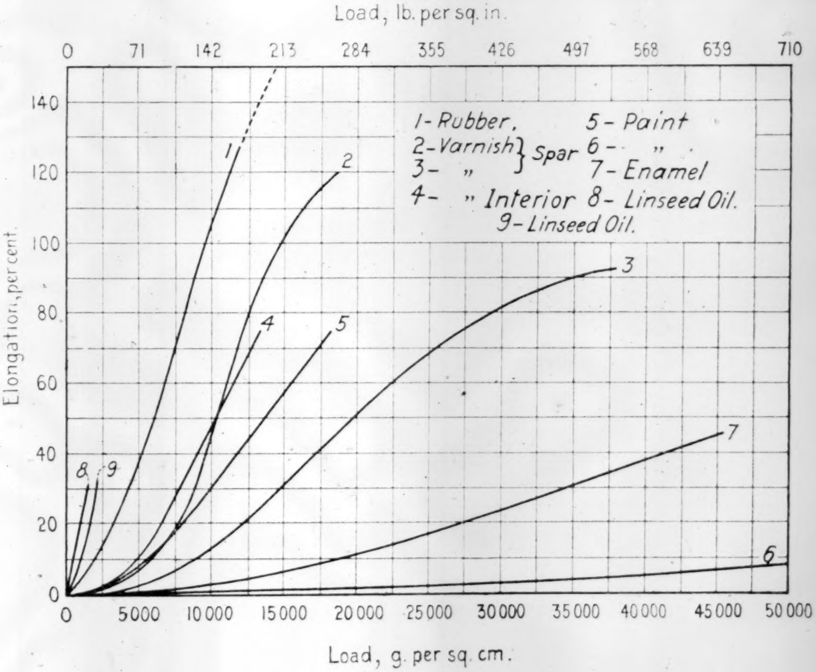


FIG. 1.—Typical Forms of Stress-Strain Curves

Varnish A.—Varnish A (Fig. 2) is a China wood oil - ester gum product with 27 gal. of oil to each 100 lb. of gum reduced with 47.4 per cent volatile consisting of $\frac{1}{2}$ turpentine and $\frac{1}{2}$ turpentine substitute. The stress-strain curves show the following characteristics similar to those previously observed for spar varnishes:

1. High distensibility, which is affected only to a slight extent by changes in the adsorbed moisture content of the film.

2. High tensile strength, which is properly balanced by a well-maintained high distensibility, thus keeping the stress-strain curves centrally located in the plot.

3. A very pronounced resistance to final rupture, indicating a decidedly tough, rubber-like structure.

From these considerations certain results may be expected with this varnish upon exposure. In the first place, it should not be easily affected by moisture. Further, we would not expect this varnish to crack under extremely dry atmospheric conditions, nor when subjected to violent expansion and contraction due to temperature changes. Finally, the good balance between distensibility and strength indicates a tough material, which is not easily abraded and retains its gloss.

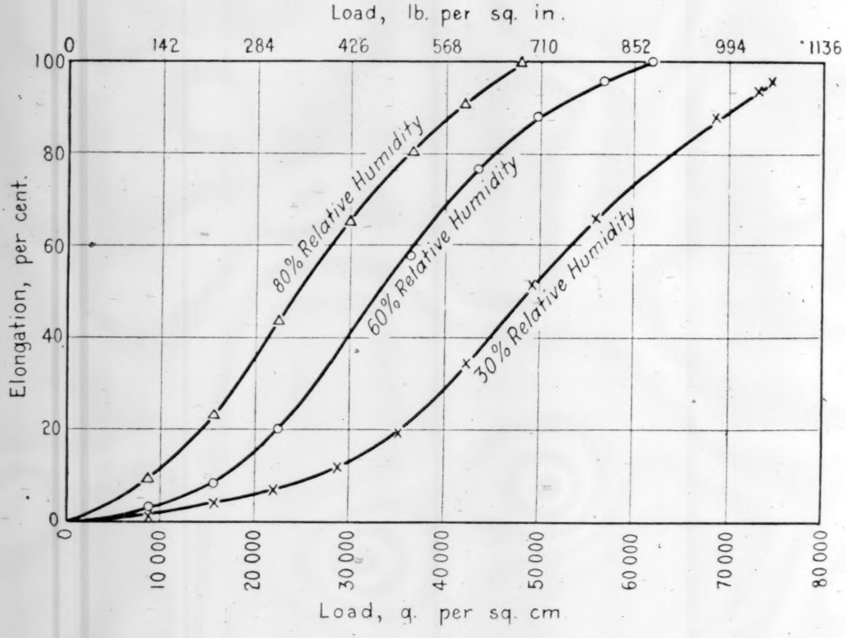


FIG. 2.—Stress-Strain Curves for Varnish A, China Wood Oil - Ester Gum

Varnish B.—Varnish B (Fig. 3) is a linseed oil - Kauri gum product with 27 gal. of oil to each 100 lb. of gum, reduced with 52.7 per cent volatile, consisting of $\frac{1}{2}$ turpentine and $\frac{1}{2}$ turpentine substitute. This varnish shows the following characteristics:

1. A fairly high distensibility which varies only slightly with the moisture content of the film.

2. A fairly high tensile strength, which, with the distensibility, gives a well-balanced curve centrally located on the plot.

3. Some resistance to final rupture as evidenced by the final outward swing of the curves.

We would expect this varnish to be comparatively unaffected by moisture or moisture changes. Its tendency to crack might be slightly greater than that of Varnish A. The film is not so tough as that of Varnish A.

Varnish C.—Varnish C (Fig. 4) is a linseed oil - lime-treated rosin product with 27 gal. of oil to each 100 lb. of gum reduced with 45.6 per cent turpentine substitute. In this varnish we have an entirely different product from any previously considered, as indicated by the following characteristics of the curves:

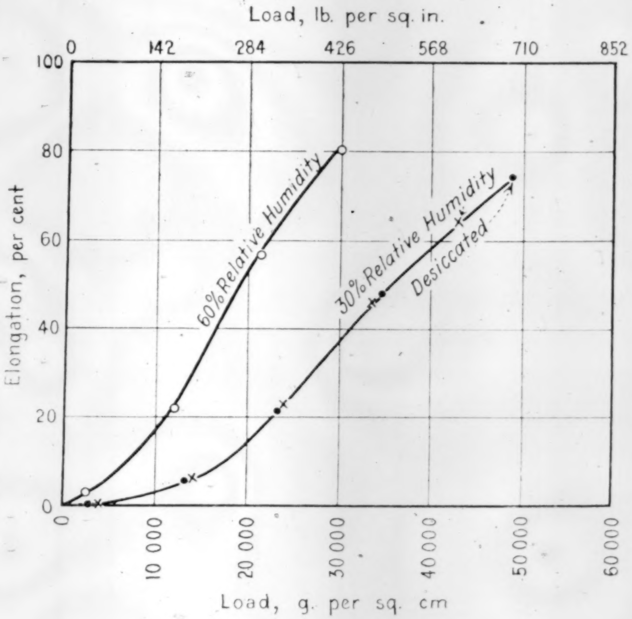


FIG. 3.—Stress-Strain Curves for Varnish B, Linseed Oil - Kauri Gum

1. The distensibility varies tremendously with changes in moisture content of the film.

2. The tensile strength is only moderately high and the curves are well balanced only at intermediate humidities.

3. The film displays a certain amount of resistance to rupture at intermediate humidities, but loses this evidence of toughness at both high and low humidities.

This is distinctly not a varnish for out-door exposures. It would be badly affected by moisture and moisture changes. In dry climates, subject to severe temperature variations, we would expect it to crack. On the other hand, if exposed at certain uniformly maintained humidities, it should give service, as indicated by the well-balanced curves at 60 per cent relative humidity.

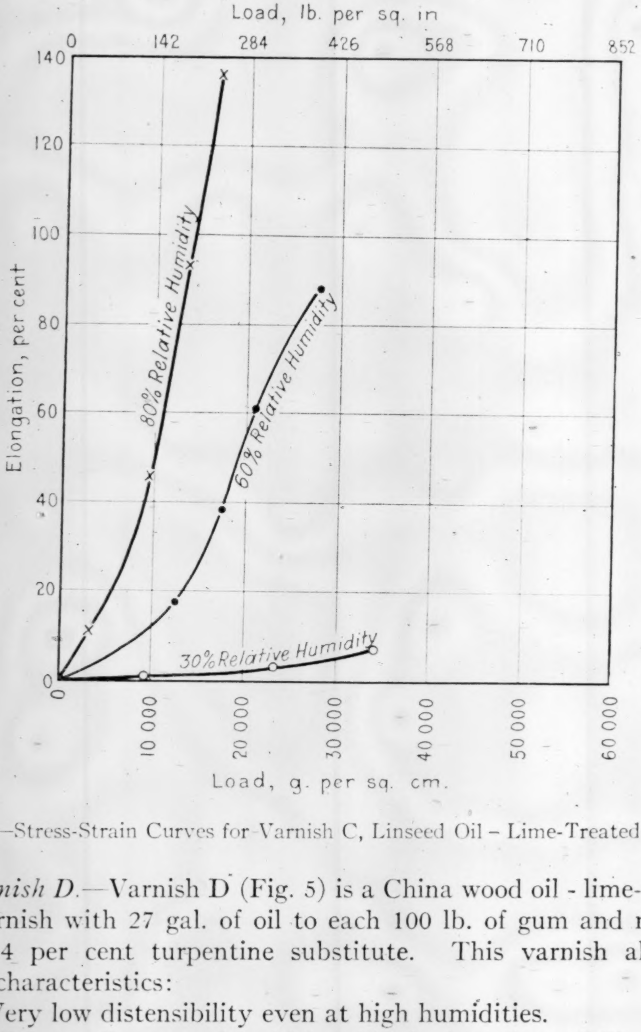


FIG. 4.—Stress-Strain Curves for Varnish C, Linseed Oil - Lime-Treated Rosin

Varnish D.—Varnish D (Fig. 5) is a China wood oil - lime-treated rosin varnish with 27 gal. of oil to each 100 lb. of gum and reduced with 45.4 per cent turpentine substitute. This varnish also has distinct characteristics:

1. Very low distensibility even at high humidities.
2. High tensile strength, which, with the low distensibility, gives a poorly-balanced curve.

3. The total effect of changes in adsorbed moisture content is relatively slight. In this respect the varnish may be classed with Varnish A.

4. Absolutely no evidence of a final increasing resistance to rupture.

We would expect this varnish to resist uniformly wet conditions well, but any variations from moist to dry exposure conditions would result in cracking. Because of the brittleness of the film, scratches might be expected to show more than, for example, on Varnishes A or B. Under moist conditions or very uniform conditions, its retention of gloss should be quite satisfactory.

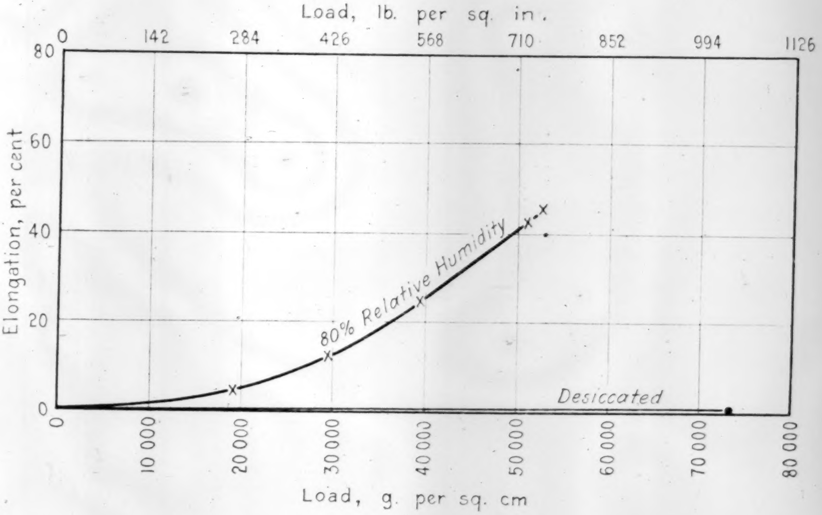


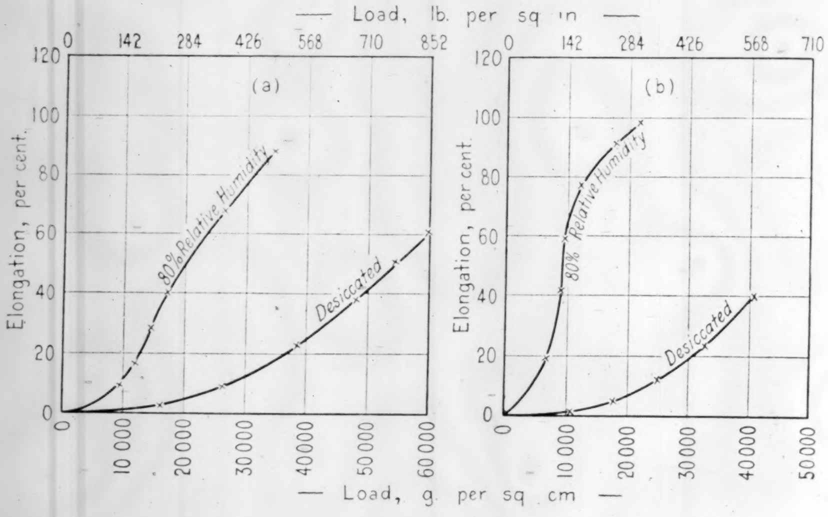
FIG. 5.—Stress-Strain Curves for Varnish D, China Wood Oil – Lime-Treated Rosin

TEST ON FILMS DRIED BY NORMAL OXIDATION

Sections of unbaked films were allowed to oxidize at room temperatures for 100 days. After this time, Varnishes C and D were so brittle that they were not successfully removed from the amalgamated surfaces. However, specimens of Varnishes A and B were obtained and tested at high and low relative humidities.

Fig. 6 (*a*) shows the results with Varnish A. The period of normal oxidation has resulted in curves having approximately the same location on the plot as those taken after baking. However, there are certain differences. For example, the final outward bend of the curve is pronounced only at high relative humidities and has apparently disappeared entirely at low humidities. Then, also, the effect of moisture content on the distensibility has slightly increased which would lead us to believe that the water resistance of the unbaked film will be lower than that of the baked film (see Fig. 2).

Figure 6 (*b*) of Varnish B is interesting because it reveals the same differences between the baked and unbaked films. Here, however, the effect of adsorbed moisture on the distensibility is even more pronounced and we would suspect that this varnish, when unbaked, would be slightly less water-resistant than Varnish A. Accordingly, we might also suspect (by comparing Figs. 2 and 3 with Figs. 6 (*a*) and 6 (*b*)) that any difference in the water resistance of Varnishes A and B would be less marked after the films had been baked. The physical changes that apparently follow the baking of a varnish film deserve further investigation.



(*a*) Varnish A (*b*) Varnish B

FIG. 6.—Stress-Strain Curves for Varnishes after Normal Oxidation for 100 days

EFFECT OF ADSORBED MOISTURE ON OTHER DISTENSIBILITY TESTS

The very pronounced effect of adsorbed moisture on the distensibilities of varnishes suggests that care in maintaining a uniform relative humidity during the period just before Kauri reduction test plates are bent, would be essential for accurate and comparable results. Quite possibly for such Varnishes as A, B and D, the errors introduced by humidity variations would be moderate, but it is apparent that even small variations in humidity might cause appreciable errors in testing a varnish which has its distensibility greatly affected by the adsorbed moisture content as does Varnish C.

Examination of the results already reported to Committee D-1 for the Kauri reduction tests on these varnishes[1] would seem to verify this, for the number of extreme variations from the average results reported for Varnish C are greater by at least 100 per cent than for any of the other varnishes.

TABLE I.—EFFECT OF RELATIVE HUMIDITY DURING COOLING PERIOD (1 HOUR) ON THE RESULTS OF THE KAURI REDUCTION TEST

Reduction, per cent	Results of Kauri Reduction Test			
	Desiccated over $CaCl_2$	30 Per Cent Relative Humidity	60 Per Cent Relative Humidity	80 Per Cent Relative Humidity
VARNISH A				
70	Passed	Passed	Passed	Passed
80	Slightly cracked	Slight traces	Passed	Passed
90	....	Badly cracked	Badly cracked	Considerably cracked
100	....	Very badly cracked	Very badly cracked	Badly cracked
VARNISH B				
40	Passed	Passed	Passed	Passed
50	Passed	Passed	Passed	Passed
60	Passed	Passed	Passed	Passed
70	Badly cracked	Very slightly cracked	Passed[1]	Passed[1]
VARNISH C				
0	Passed	Passed	Passed	Passed
10	Passed	Passed	Passed	Passed
20	Cracked	Passed	Passed	Passed
30	Cracked	Cracked	Passed	Passed
40	Cracked	Cracked	Cracked	Passed
50	Cracked	Cracked	Cracked	Cracked
VARNISH D				
0	Passed	Passed	Passed	....
10	Badly cracked	Slightly cracked	Passed	Passed
20	Very badly cracked	Badly cracked	Very slightly cracked	Very slightly cracked
30	....	Very badly cracked	Slightly cracked	Slightly cracked

[1] Not enough varnish on hand to complete series.

Experiments further prove that the relative humidity to which the baked varnishes are exposed during the hour after baking and just prior to the bending test, may have a pronounced effect on the results of the Kauri reduction test.

Varnish C was reduced by amounts varying from zero to 50-per-cent reduction, and the test carried out exactly according to directions, except that 5 minutes after being removed from the oven a panel of each was placed in (1) a desiccator; (2) a humidor maintained at 30 per cent relative humidity (by H_2SO_4 solution); (3) a humidor at 60 per cent relative humidity; (4) a humidor at 80 per cent relative humidity. After 55 minutes, the panels were removed one by one and bent over the standard $\frac{1}{8}$-in. rod.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 375 (1922).

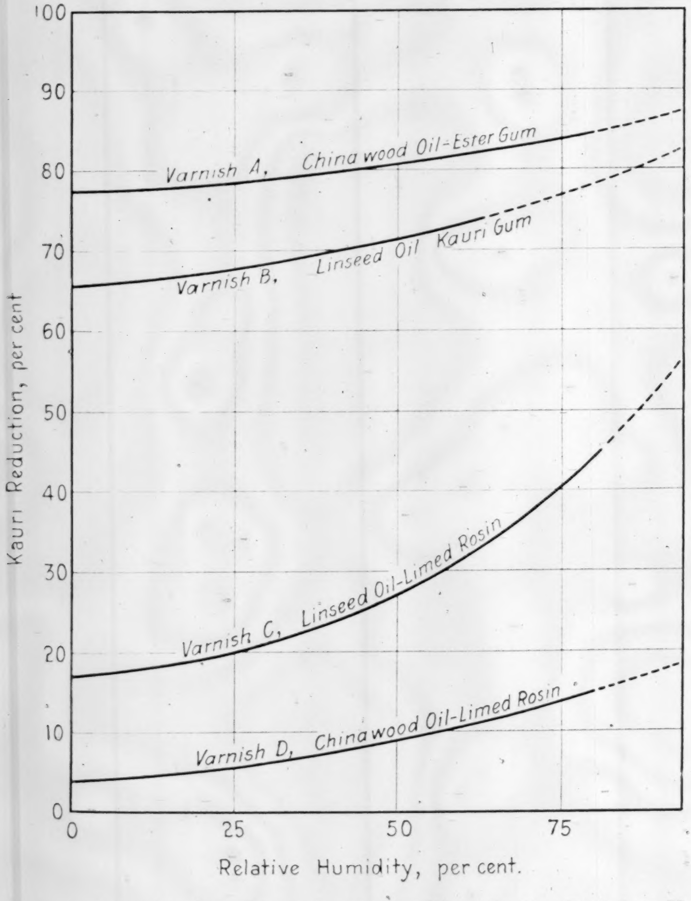

FIG. 7.—Effect of Relative Humidity During Final Cooling Period on Kauri Reduction Test Values

Small additional portions of Varnishes A, B and D were obtained and the experiment carried out on these, as described above. The results are summarized in Tables I and II.

The results of this experiment are shown graphically in Fig. 7. In drawing these curves, the true cracking points have been approximated from the extent of the cracking observed on each panel. It will be noted that the results are in close agreement with what is predicted by the stress-strain curves.

Obviously, if the Kauri reduction test is to be universally applied, controlled humidity conditions are essential during the period just prior to the bending test. Availability and ease of manipulation recommend the common method of desiccation over $CaCl_2$.

A possible alternative would be to reduce from one hour to a few minutes the period of exposure previous to the bending test. In view of the ease with which the humidity conditions can be standardized and controlled, the advisability of adopting the latter course would be subject to question.

TABLE II.—SUMMARY OF RESULTS OF KAURI REDUCTION TESTS ON VARNISH C COMPLETED AT VARIOUS RELATIVE HUMIDITIES

RELATIVE HUMIDITY	REDUCTION, PER CENT	REMARKS
Desiccated ($CaCl_2$)	10–20	End point nearer 20 per cent[1]
30 per cent	20–30	" " " 20 "
60 "	30–40	" " " 30 "
80 "	40–50	" " " 40 "

CONCLUSIONS

Certain general observations from these tests should be emphasized:

1. Differences in the physical properties of varnishes, depending on their composition and method of preparation, can be graphically demonstrated by means of stress-strain diagrams in such a manner as to indicate their probable field of usefulness.
2. Adsorbed moisture in the film so profoundly affects the physical characteristics of a varnish film that humidity and humidity changes may be the determining factor in the useful service the varnish gives upon exposure.
3. Physical tests, such as hardness determinations and cracking tests, should be carried out under controlled humidity as well as under controlled temperature conditions.

For further comparison and study of the results of these tests, reference should be made to other laboratory and exposure tests which have been,[2] or will be published in connection with the sub-committee's reports on these varnishes.

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[1] Moisture equilibria curves for oxidizing oil films generally show great increases in the amount of moisture adsorbed beyond 50 to 60 per cent relative humidity. This flatness of the first part of the moisture equilibria curve might account for the close grouping of the end points for desiccated and 30 per cent relative humidity, while the end points at 60 to 80 per cent relative humidity are spread somewhat further apart.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 375 (1922).

REPORT OF SUB-COMMITTEE XIII ON SHELLAC

This sub-committee was reorganized and members appointed in October, 1922. The first meeting was held at the Chemists' Club, New York City, on November 27, 1922.

Mr. L. L. Steele of the U. S. Bureau of Standards, Washington, D. C., submitted a method for the rapid determination of the alcohol insoluble matter in shellac. It was decided to carry out collaborative work on this method. Four samples of shellac were selected. These were ground and very thoroughly mixed. Duplicate analyses of each were made in the chairman's laboratory by the standard method of the United States Shellac Importers' Association, and very close checks were obtained on each shellac. These results indicated that the samples were well mixed. The samples were bottled and labeled and sent to each member with instructions to analyze each shellac by the Gooch crucible method of Dr. Steele and also by the United States Shellac Importers' Association Method using 99½-per-cent methyl alcohol and with Formula No. 1 and Formula No. 30 denatured alcohols. The tabulated report of the work contained 140 determinations, each of the figures representing averages of at least two tests.

The results indicated lower figures with the United States Shellac Importers' Association Method using the denatured alcohols. The objection to changing over to denatured alcohol before was that Formula No. 1 or pure grain alcohol was so difficult to obtain. We have now the Formula No. 30 which can be obtained by any chemical laboratory.

The Gooch crucible method gave good results with the regular orange flake shellacs, which are usually met with in the trade. It is necessary to follow the method exactly as described, especially to be sure to have the alcohol at or near the boiling point. The determination can be rapidly carried out. It is not difficult to prepare the Gooch crucible, which is a more or less standard piece of chemical ware to be found in almost every laboratory.

The sub-committee met in Washington at the U. S. Bureau of Standards on March 22, 1923. It was decided at this meeting to propose as tentative the continuous extraction method, a method similar to the present A.S.T.M. Standard for the alcohol insoluble and the Gooch crucible method. Some changes were suggested for the rosin method.

It is recommended that these tests, issued under the title "Tentative Methods of Testing Shellac"[1] be accepted for publication as tentative, to supersede, when adopted, the present Standard Methods of Testing Shellac (Serial Designation: D 29 - 17).[2]

Respectfully submitted on behalf of the sub-committee,

JOHN W. PAISLEY,
Chairman.

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[1] See p. 658.—ED.

[2] 1921 Book of A.S.T.M. Standards.

REPORT OF SUB-COMMITTEE XIV ON PREPARATION OF IRON AND STEEL SURFACES FOR PAINTING

Sub-Committee XIV submits herewith a report of further inspections of the test panels exposed at Altoona, Pa., and Brooklyn, N. Y. These panels were originally exposed in February, 1917, and the exposure in each case was practically continuous up to the time of last inspection in November, 1922, except in the case of Panel No. 10 at Brooklyn, which was withdrawn in May, 1921. The exposure up to November, 1922, therefore, covered a period of some five years and nine months.

The inspection of the panels in November, 1922, was the fifth, previous inspections having been made in the years 1918, 1919, 1920 and 1921.

FIFTH INSPECTION OF TEST PANELS AT ALTOONA, PA., ON NOVEMBER 24, 1922

The inspection was made by sub-committee members Jennings, McDonnell, Sabin and Carpenter, the panels being inspected in place on the exposure racks. These panels, which had up to the time of last previous exposure (with the exception of panel No. 10) shown practically no signs of failure, were noted as beginning to show such signs. Up to the time of this inspection there had not been sufficient deterioration in the coatings of the Altoona panels to warrant rating them on a percentage basis, as had been done in the case of the Brooklyn panels beginning with the October, 1920, inspection. The Altoona panels, therefore, were given comparative ratings at this inspection. The ratings of the various sub-committee members varied slightly, so the range is given. The following is a statement of the ratings with brief descriptions of the panels, so as to give a general idea of the situation.

TEST ON NEW STEEL, ALTOONA

		DESCRIPTION		RATING
Panel No.	1.	Clean surface, mill scale intact		75 to 80 per cent
" No.	2.	Mill scale broken, some rust, hand cleaned		85 per cent
" No.	10.	5 months' exposure to weather; hand cleaned		50 "
" No.	3.	Sand blasted	Various conditions of atmosphere and temperature at time of painting	90 to 95 per cent
" No.	4.	Sand blasted		86 to 90 "
" No.	5.	Sand blasted		90 to 95 "
" No.	6.	Sand blasted		83 to 90 "
" No.	7.[a]	Sand blasted		88 to 90 "

---

[a] Seven days' exposure to weather before painting.

TEST ON NEW STEEL, ALTOONA—*Continued*

	DESCRIPTION	RATING
Panel No. 16.	Incompletely sand blasted	80 to 85 per cent
" No. 8.	Pickled, hot water rinsed, neutraized, water washed	90 to 95 "
" No. 9.[a]	Pickled, cleaned as for Panel No. 8	85 per cent
" No. 11.	Pickled, washed with cold water under pressure	90 to 95 per cent

TEST ON OLD STEEL, ALTOONA

	DESCRIPTION	RATING
Panel No. 12.	Cleaned with wire brush	78 per cent
" No. 13.	Cleaned with benzine, scraper and wire brush	80 "
" No. 14.	Benzine applied and burned with torch, cleaned with scraper and wire brush	85 "
" No. 15.	Sand blasted	86 "

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[a] Seven days' exposure to weather before painting.

A set of photographs of the panels was taken by arrangement of Mr. McDonnell during the winter of 1923, so as to better preserve the record of the condition of these panels.

FIFTH INSPECTION OF TEST PANELS AT BROOKLYN, N. Y., ON NOVEMBER 25, 1922

The Brooklyn panels were inspected on November 25, 1922, this inspection being made by sub-committee members Cheesman, Sabin and Carpenter and by Mr. Gearhart, a master painter of the Pennsylvania Railroad, representing Mr. McDonnell.

The test panels were examined indoors, having been taken from the exposure racks for that purpose. The panels were rated on a percentage basis and it was decided that all, with the exception of Nos. 6 and 14, were in such an advanced stage of deterioration that they should not be re-exposed.

The ratings are stated below briefly in the same form as above for the Altoona panels.

TEST ON NEW STEEL, BROOKLYN

	DESCRIPTION		RATING
Panel No. 1.	Clean surface, mill scale intact		60 per cent
" No. 2.	Mill scale broken; some rust; hand cleaned		40 "
" No. 3.	Sand blasted	Various conditions of atmosphere and temperature at time of painting	50 "
" No. 4.	Sand blasted		25 "
" No. 5.	Sand blasted		40 "
" No. 6.	Sand blasted		80 "
" No. 7.[a]	Sand blasted		60 "

---

[a] Seven days' exposure to weather before painting.

TEST ON NEW STEEL, BROOKLYN—*Continued*

	DESCRIPTION	RATING
Panel No. 16.	Incompletely sand blasted	65 per cent
" No. 8.	Pickled, hot water rinsed, neutralized, water washed	60 "
" No. 9.[a]	Pickled, cleaned as for Panel No. 8	25 "
" No. 11.	Pickled, washed with cold water under pressure	25 "

TEST ON OLD STEEL, BROOKLYN

	DESCRIPTION	RATING
Panel No. 12.	Cleaned with wire brush	40 per cent
" No. 13.	Cleaned with benzine, scraper and wire brush	50 "
" No. 14.	Benzine applied and burned with torch; cleaned with scraper and wire brush	80 "
" No. 15.	Sand blasted	40 "

[a] Seven days' exposure to weather before painting.

A set of photographs of the Brooklyn panels was taken later by an employee of the National Lead Co. through arrangement by Messrs. G. W. Thompson and R. L. Hallett of that company. These photographs and those of the previous inspection, May 25, 1921, have been reproduced and are included in the appendix to this report with a brief description explaining the test for each panel and showing the ratings. The illustrations represent exposures of 4 years, 4 months and 5 years, 9 months, respectively. All panels were painted with two coats of iron oxide paint after treatment as outlined under the figures. For a full description of the preparation of the test panels see the report of the sub-committee for 1917.[1]

For a resumé of the test data and preliminary statement of test indications, see the report of the sub-committee for 1921.[2]

In conclusion it is deemed well to state that the test of the Altoona panels is still in progress without definite results up to last inspection; that the test of the original Brooklyn panels has been concluded with the exception of panels Nos. 6 and 14, with the results reported. The sub-committee is giving thought to possible continuation of the tests on the Brooklyn panels following a re-preparation of the surfaces but is not ready to submit any definite recommendation.

Respectfully submitted on behalf of the sub-committee,

A. W. CARPENTER,
Chairman.

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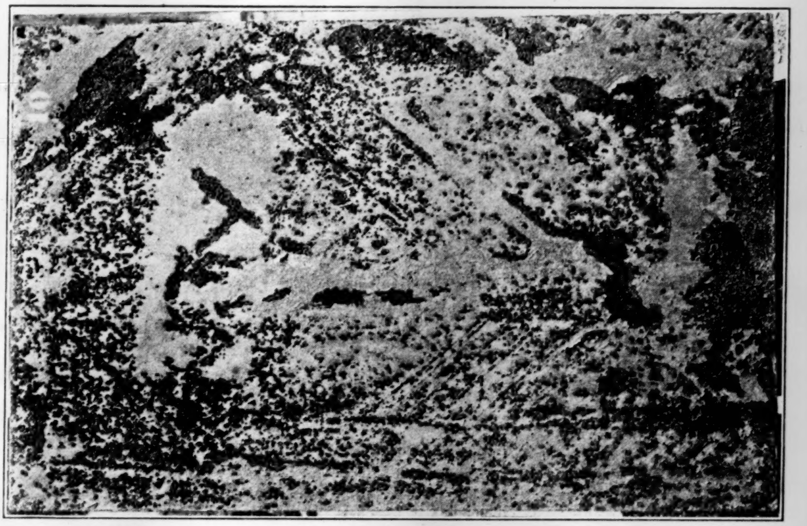
[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 451 (1917).

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 345 (1921).

APPENDIX

PHOTOGRAPHS OF BROOKLYN PANELS, INSPECTIONS OF MAY 25, 1921, AND NOVEMBER 25, 1922.



Inspection May 25, 1921.

FIG. 1.—Panel No. 10, New Steel—Ordinary Cleaning

As received from mill, was exposed to weather $5\frac{1}{2}$ months. Became deeply rusted, especially along diagonal lines between which some mill scale remained. Surface cleaned with scraper and wire brush. Painted in warm, dry room.

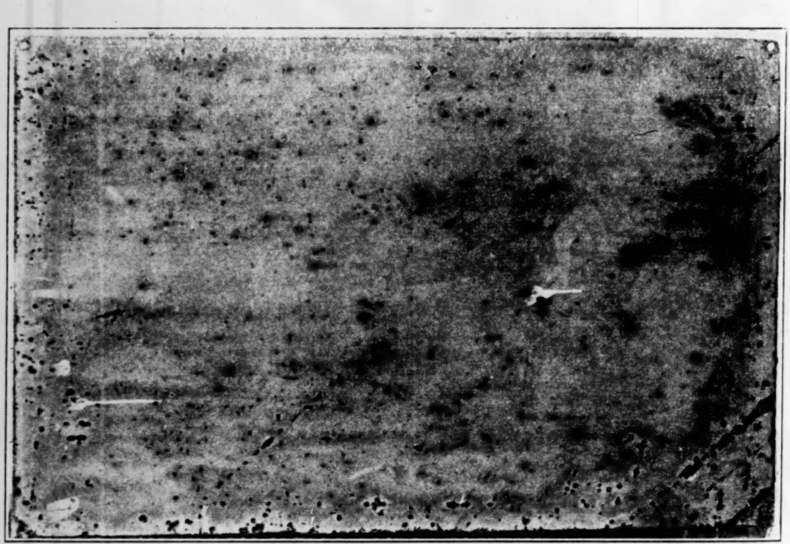
Rating.—Inspection May 25, 1921:

Condition much the same as last inspection. For practical purposes useless to continue test. (Decided to send plate to Altoona to have one-half sandblasted and the other half scraped, wire brushed and retested.)

Inspection November 25, 1922:

Panel now at Altoona, reprepared and re-exposed.

Inspection May 25, 1921, Rated 80 per cent

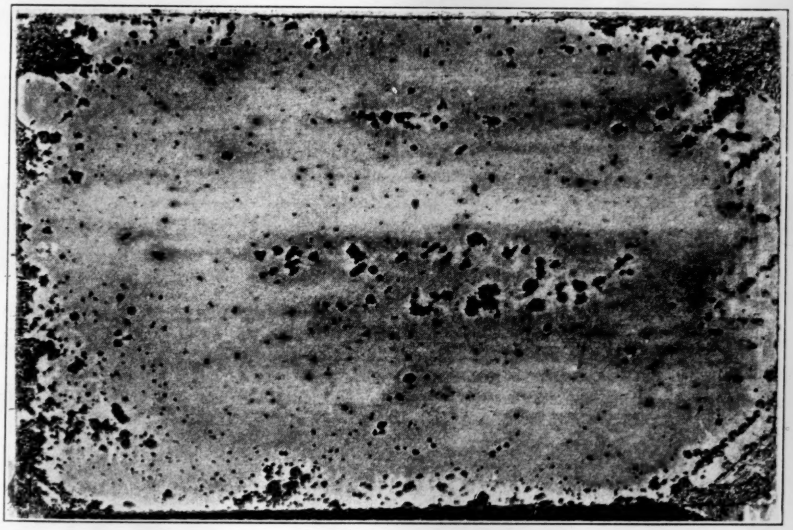


Inspection November 25, 1922, Rated 60 per cent

FIG. 2.—Panel No. 1, New Steel—No Surface Treatment

As received from mill; surface clean and free from rust, mill scale intact. Paint applied in warm, dry room.

Inspection May 25, 1921, Rated 60 per cent

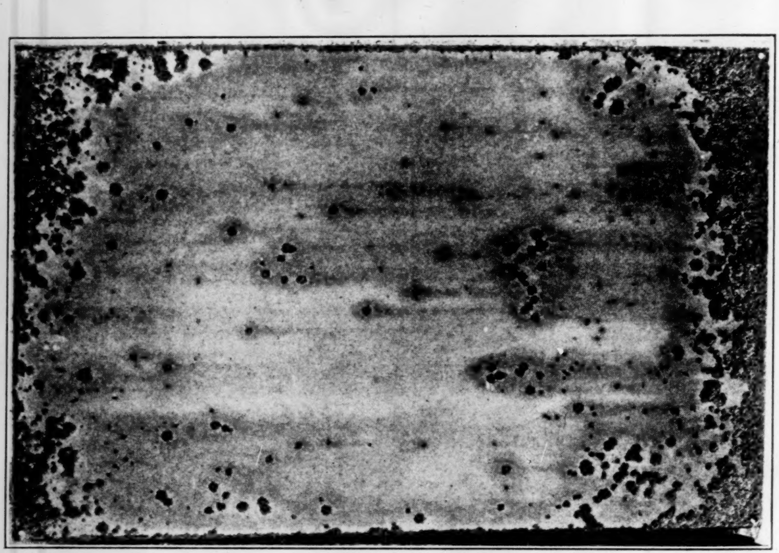


Inspection November 25, 1922, Rated 40 per cent

FIG. 3.—Panel No. 2, New Steel—Ordinary Cleaning

Surface rather badly abraded, about 25 per cent of mill scale gone, slightly rusted, also smeared with tallow. Washed with benzine, scraped and wire-brushed. Painted in warm, dry room.

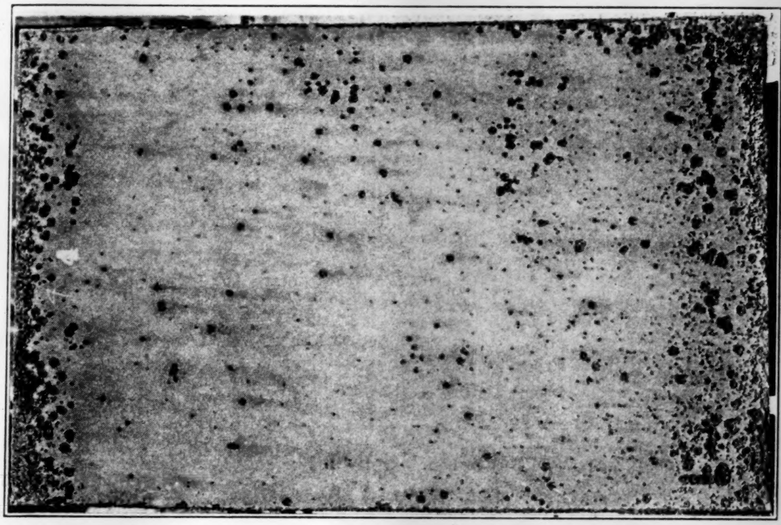
Inspection May 25, 1921, Rated 65 per cent



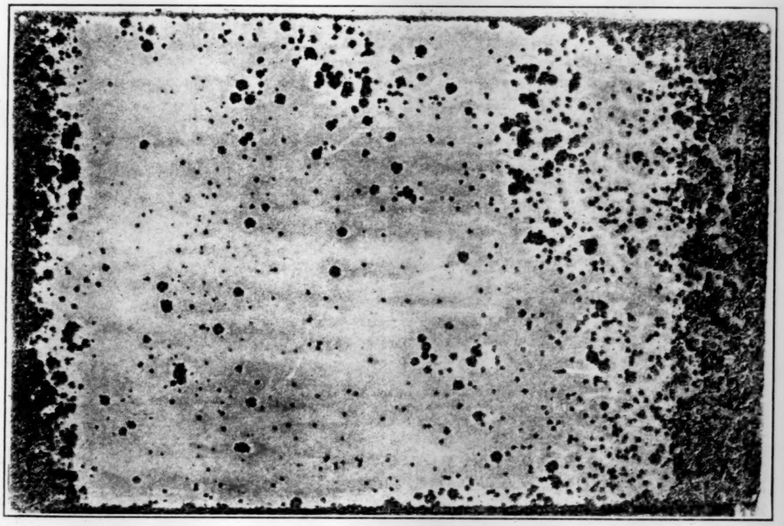
Inspection November 25, 1922, Rated 50 per cent

FIG. 4.—Panel No. 3, New Steel, Sandblasted

Painted immediately thereafter in warm, dry room.



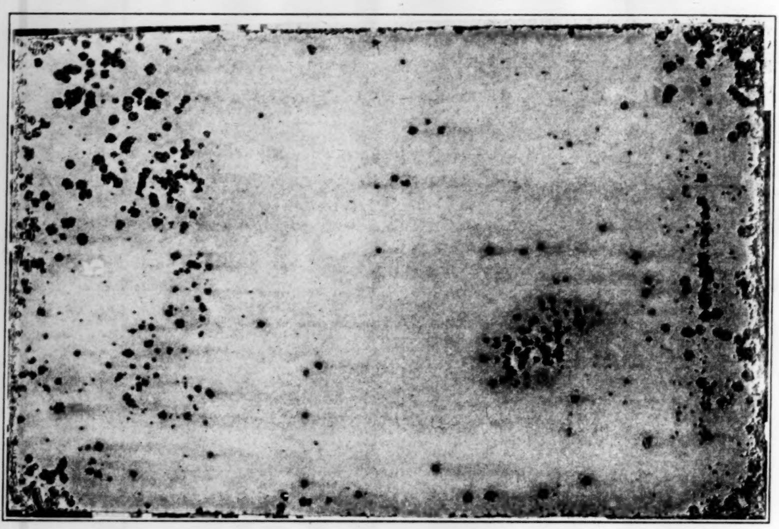
Inspection May 25, 1921, Rated 40 per cent



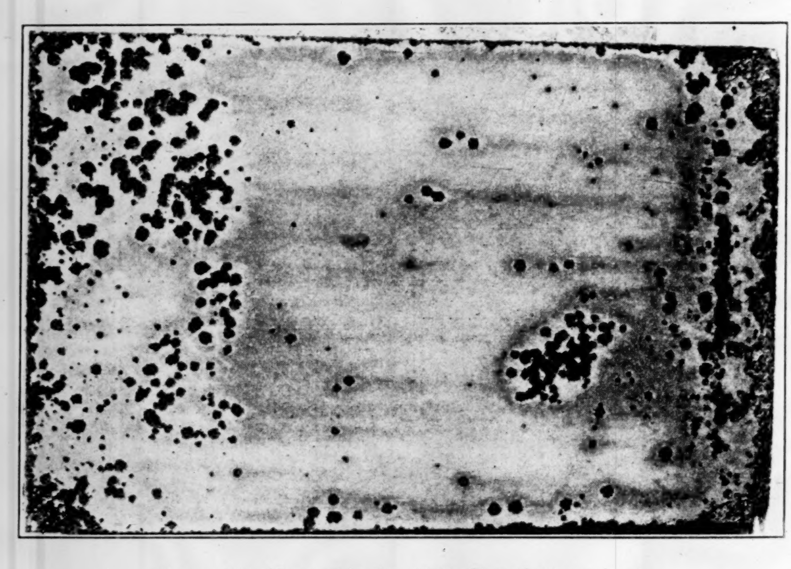
Inspection November 25, 1922, Rated 25 per cent

Fig. 5—Panel No. 4, New Steel, Sandblasted

Heated immediately thereafter in an oven to 225° F. Painted while still warm.



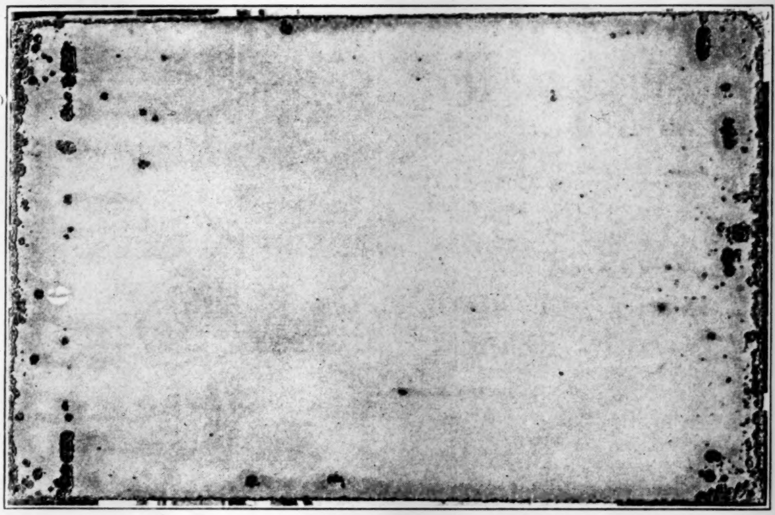
Inspection May 25, 1921, Rated 45 per cent



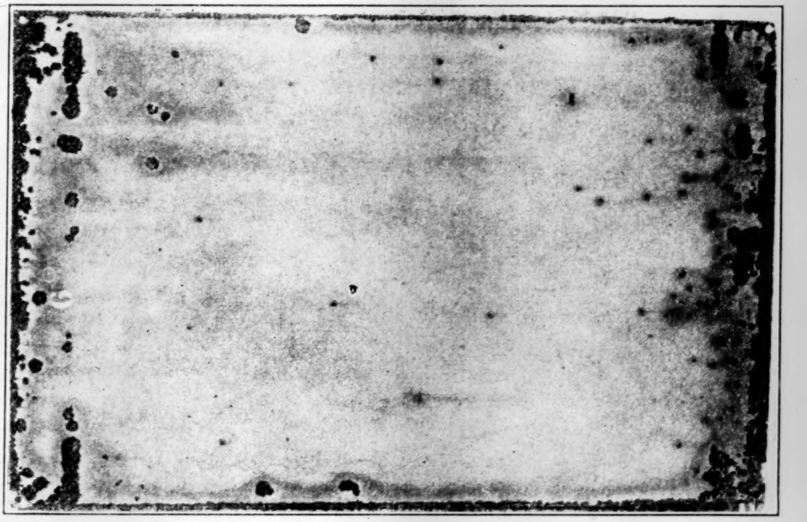
Inspection November 25, 1922, Rated 40 per cent

FIG. 6.—Panel No. 5, New Steel, Sandblasted

Placed in cool damp room for forty minutes and painted therein. Temperature when painted 43 to 44° F.



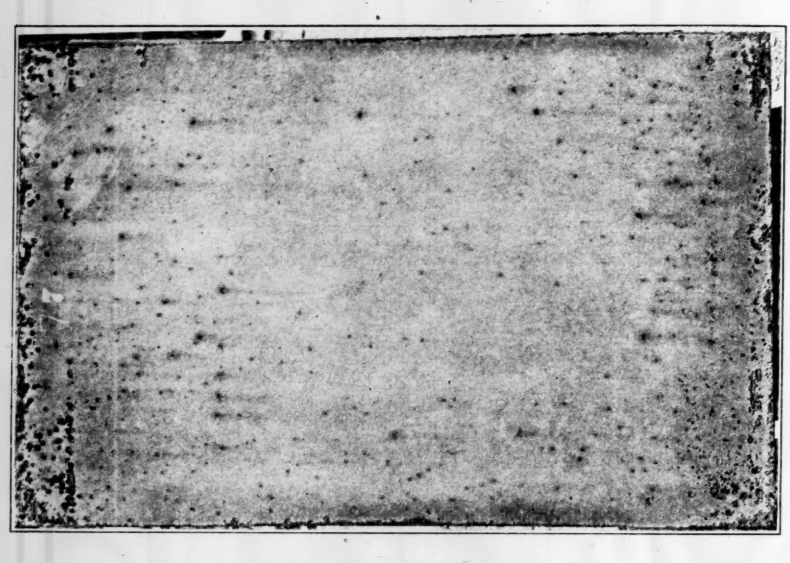
Inspection May 25, 1921, Rated 90 per cent



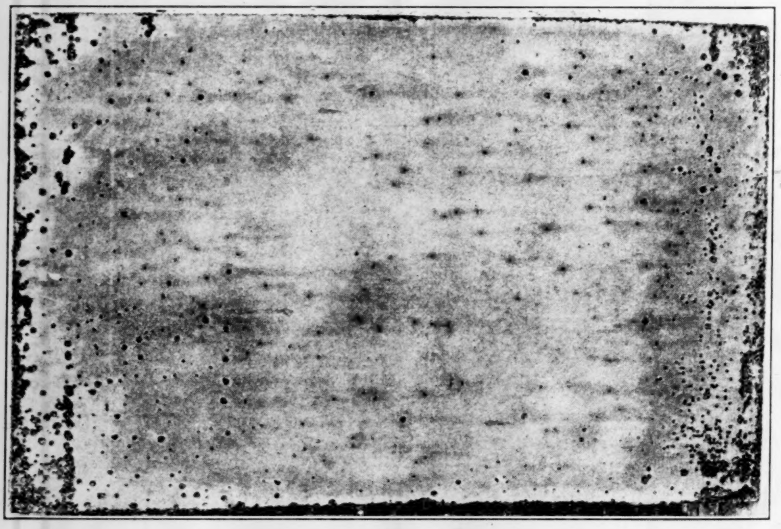
Inspection November 25, 1922, Rated 80 per cent

FIG. 7.—Panel No. 6, New Steel, Sandblasted

Placed out of doors and painted there. Temperature 25 to 27° F. Both coats dried outside.



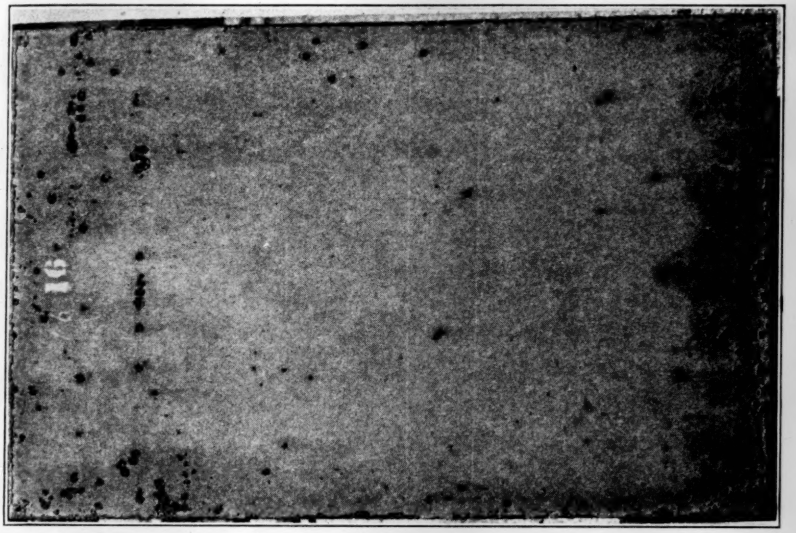
Inspection May 25, 1921, Rated 75 per cent



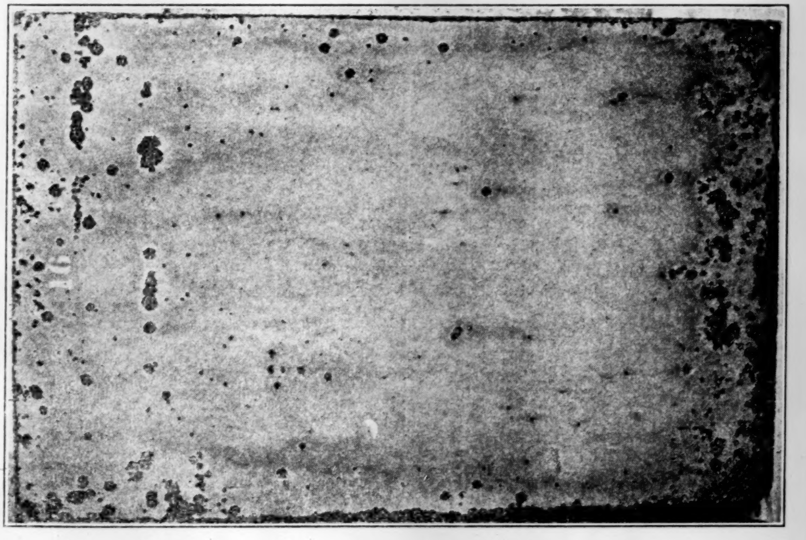
Inspection November 25, 1922, Rated 60 per cent

FIG. 8.—Panel No. 7, New Steel, Sandblasted

Exposed out of doors under cover for 7 days. Some rust developed which was not removed before painting in warm, dry room.



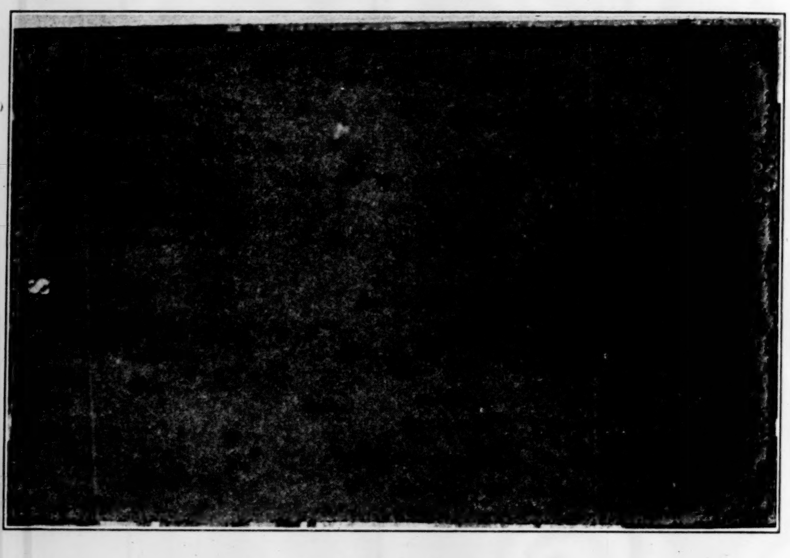
Inspection May 25, 1921, Rated 80 per cent



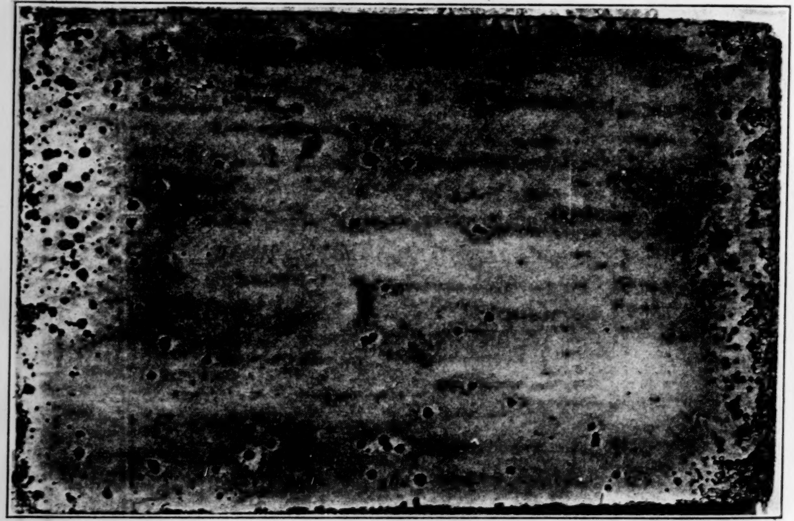
Inspection November 25, 1922, Rated 65 per cent

Fig. 9.—Panel No. 16, New Steel, Incompletely Sandblasted

Mill scale left on about 20 per cent of surface giving "spotty" appearance before painting in warm, dry room.



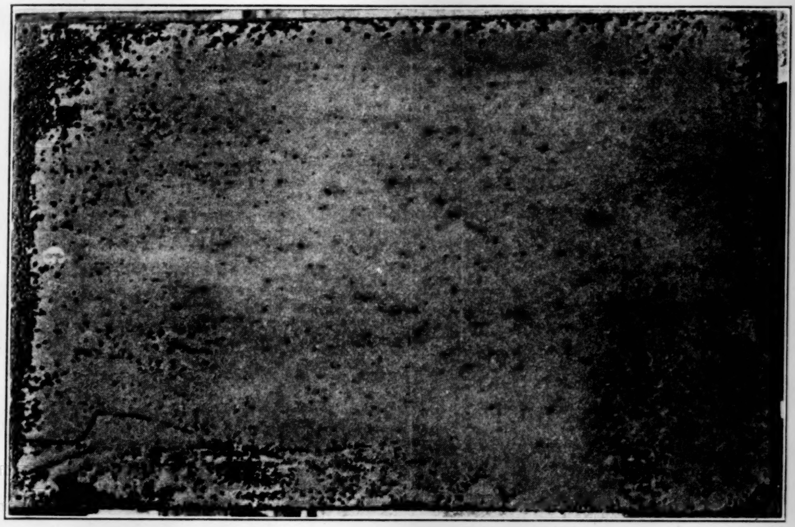
Inspection May 25, 1921, Rated 60 per cent



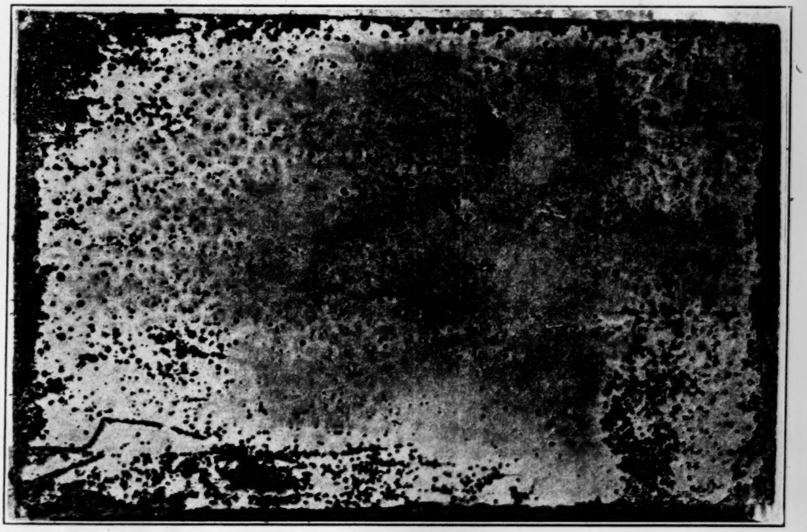
Inspection November 25, 1922, Rated 60 per cent

FIG. 10.—Panel No. 8, New Steel, Pickled

Rinsed under stream of hot water, neutralized with alkali solution and washed under stream of hot water. Painted in warm, dry room.



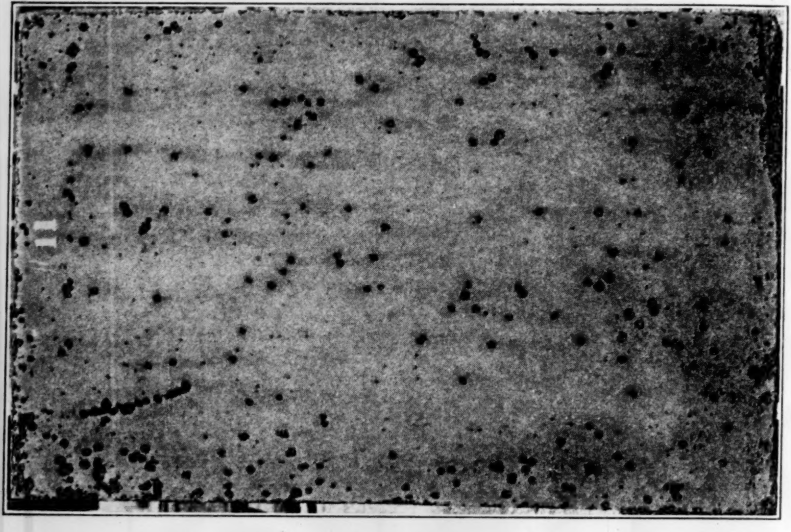
Inspection May 25, 1921, Rated 25 per cent



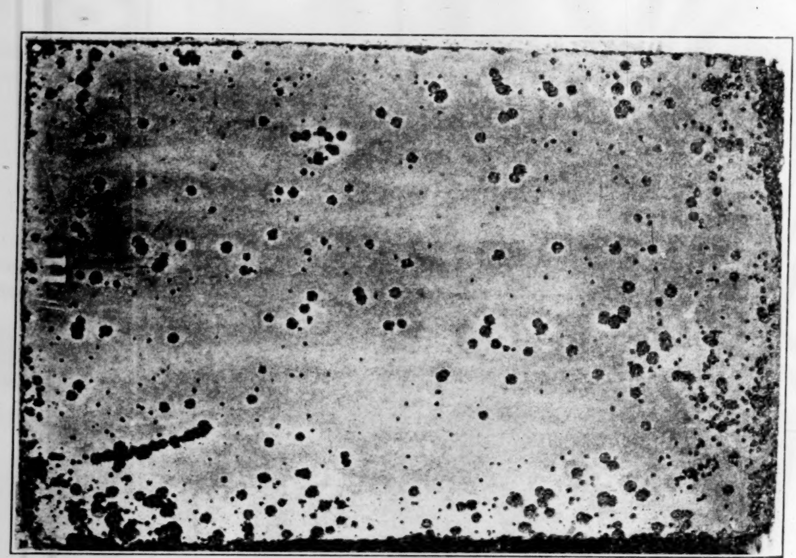
Inspection November 25, 1922, Rated 25 per cent

FIG. 11.—Panel No. 9, New Steel, Pickled

Pickled as for Panel No. 8, and exposed out of doors under cover for seven days. Some rust developed which was not removed before painting in warm, dry room.



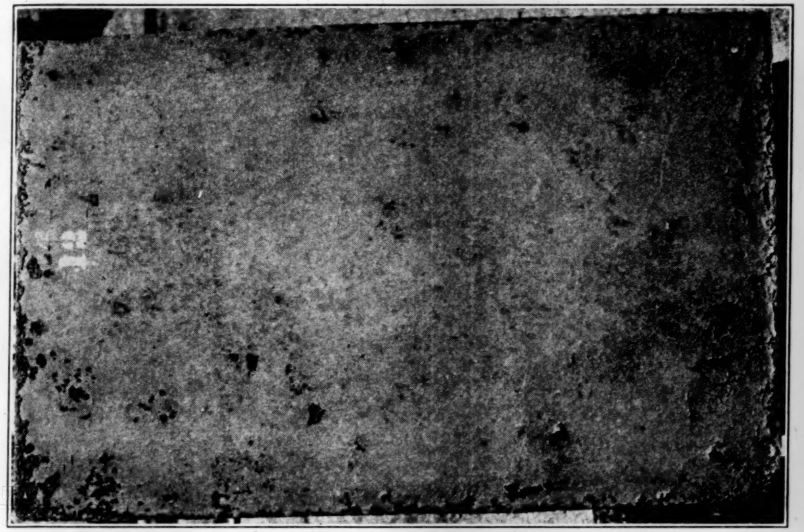
Inspection May 25, 1921, Rated 35 per cent



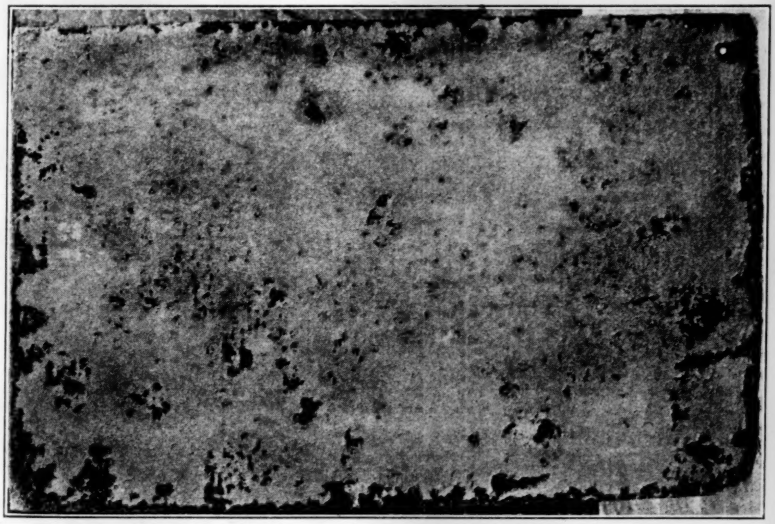
Inspection November 25, 1922, Rated 25 per cent

FIG. 12.—Panel No. 11, New Steel, Pickled

Cleaned with stream of cold water under 125 lb. per sq. in. pressure. Painted in warm, dry room.



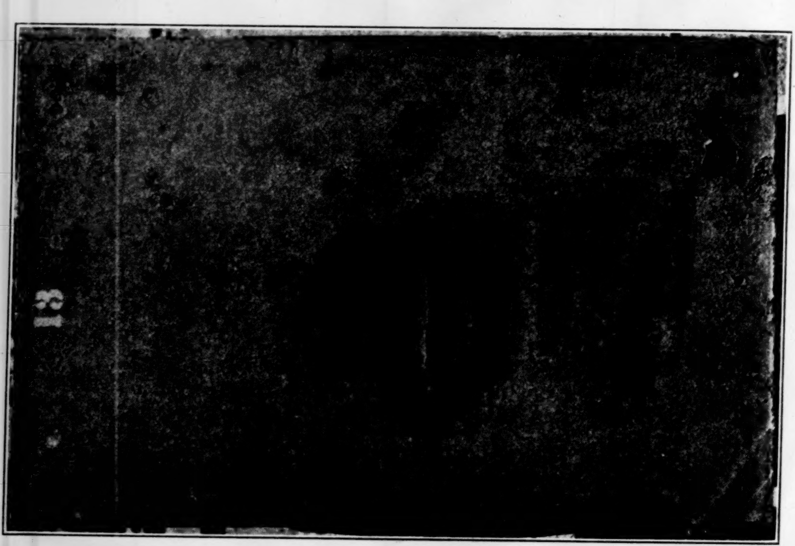
Inspection May 25, 1921, Rated 55 per cent



Inspection November 25, 1922, Rated 40 per cent

FIG. 13.—Panel No. 12, Old Steel, Ordinary Cleaning

About 25 per cent of surface bare and rusted; old paint on balance. Cleaned with wire brush only, leaving old paint on about 50 per cent of surface. Painted in warm, dry room.

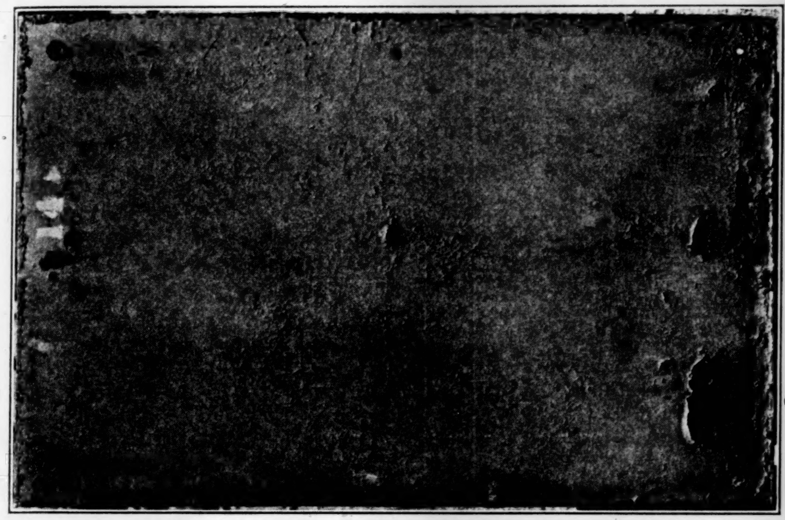


Inspection May 25, 1921, Rated 65 per cent

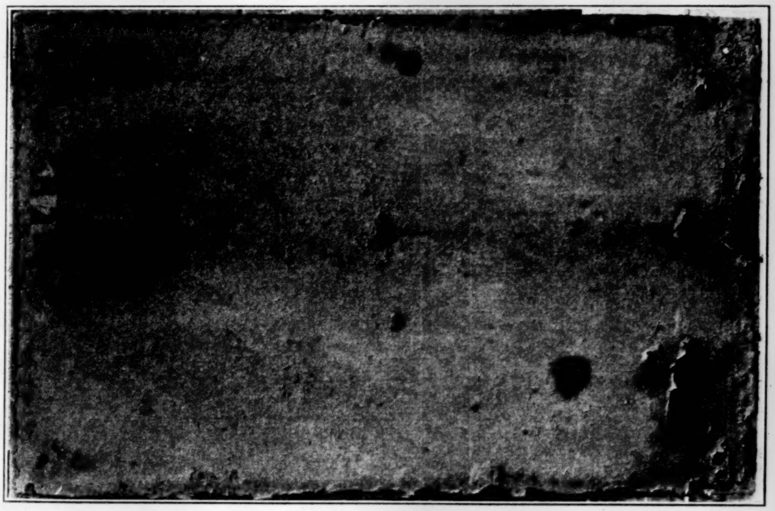
Inspection November 25, 1922, Rated 50 per cent

FIG. 14.—Panel No. 13, Old Steel, Ordinary Cleaning

Scraper, brush and benzine cleaning. About 25 per cent of surface bare and rusted in spots, old paint on balance. Washed with benzine, scraped and wire brushed leaving old paint on about 50 per cent of the surface. Painted in dry, warm room.



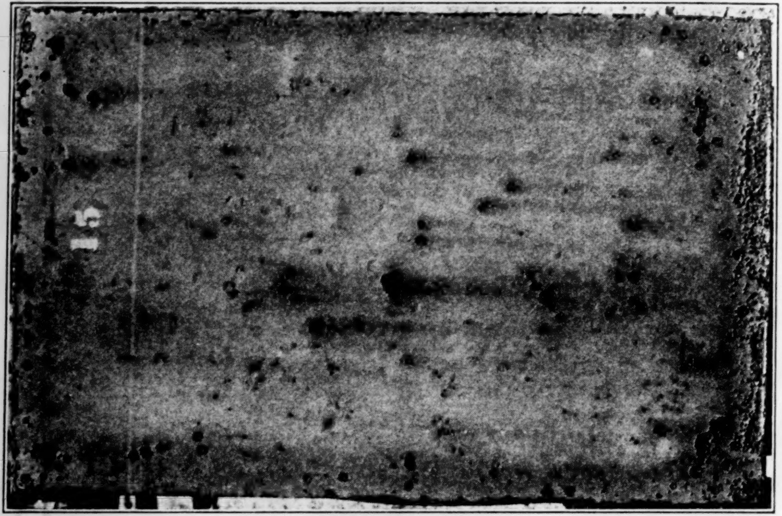
Inspection May 25, 1921, Rated 85 per cent



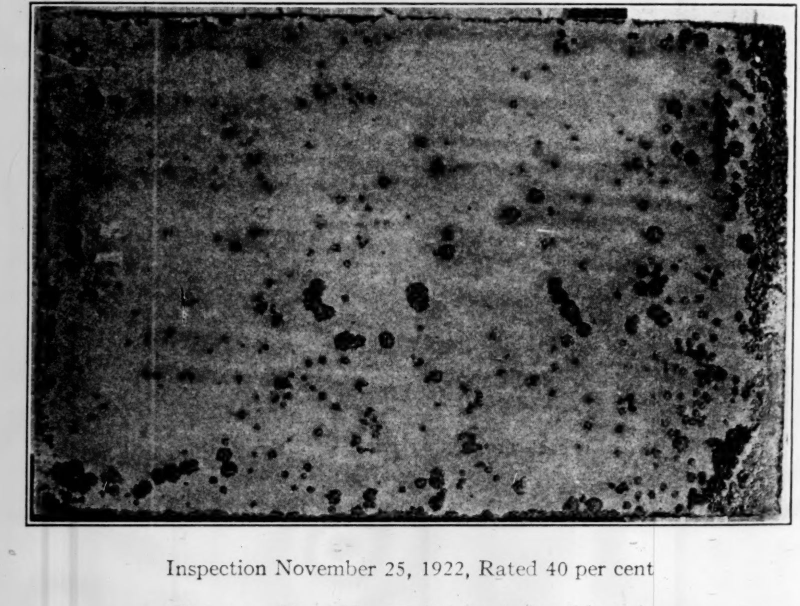
Inspection November 25, 1922, Rated 80 per cent

FIG. 15.—Panel No. 14, Old Steel, Special Hand Cleaning

Approximately 10 per cent of surface bare and rusted in spots, old paint on balance. Brushcoated with benzine over and around rust spots and benzine burned off with torch flame. Surface then scraped and wirebrushed. Painted in warm, dry room.



Inspection May 25, 1921, Rated 50 per cent



Inspection November 25, 1922, Rated 40 per cent

FIG. 16.—Panel No. 15, Old Steel, Sandblasted

Plate badly indented at several points, apparently by blows of a pick or other similar instrument. Approximately 50 per cent of surface bare and rusted. Sandblasted in warm, dry room and painted therein.

REPORT OF SUB-COMMITTEE XVIII ON PHYSICAL PROPERTIES OF PAINT MATERIALS

The program outlined for the sub-committee has been carried forward but the amount of work to be done is far too large for any definite results as yet. The primary idea was to send out samples of different colors in paints, textiles, leather, and paper, and have these measured by the various methods already more or less in common use, in order to find out whether these methods could be coordinated, or suitable factors be found which would bring them to a common fundamental basis. The paint samples were sent out to the committee members in October, but there was a delay in getting the other samples. The textiles (silk) are now ready and will be sent forward at once and it is hoped that the leather and paper samples will be available soon. There has been much difficulty in getting suitable samples.

On the paint samples some spectro-photometric curves have been sent in, and readings have been taken on the Howland and Munsell systems but the returns are not yet complete and it is too early to draw any conclusions. We have been unable to get readings by the Hess-Ives or the Jones colorimeters but hope to get them later.

The paints and textiles have been prepared so as to give both a flat and glossy surface without any change in the pigments or dyes giving the color.

A recent elaborate report of the Colorimeter Committee of the Optical Society indicates that from a scientific standpoint all the constants necessary for the complete identification of any color can be made readily by means of existing instruments, and a definite quality of light for standard illumination is also perfectly feasible. Whether or not any ready methods have been devised for measuring those differences due to variations in gloss is still an open question, at least as far as has come to our notice, but it is hoped that discussions on color may bring out information of especial value to the further work of this sub-committee.

Respectfully submitted on behalf of the sub-committee,

F. P. INGALLS,
Chairman.

REPORT OF SUB-COMMITTEE XXIII ON ANTI-FOULING PAINTS

The tests of this sub-committee reported in 1922 were chiefly for the investigation of the effect of single toxic ingredients in protective coatings for steel ships. The tests accompanying this report were a continuation of the preceding work, being for the effect mainly of two toxic ingredients in the same anti-fouling paint.

Sixteen steel panels, 30 by 60 in. in size, representing twelve anti-corrosive and anti-fouling vehicles and seventy-eight coatings, were submerged in Raritan Bay, N. J., June 3, 1922, being inspected July 21, 1922, and September 29, 1922, after which the tests were discontinued.

Practically duplicate panels were submerged in Hampton Roads, Va., on July 7, 1922, being inspected August 8, 1922, and September 27, 1922, and then discontinued.

The same coatings were submerged on panels 12 by 12 in. in size, one paint number to each panel, at Beaufort, N. C., September, 1922, and were inspected November 7, 1922, and January 18, 1923, after which the tests were abandoned.

Photographs of each panel were taken at each Raritan Bay inspection, and of some of the panels at Beaufort.

The inspectors were:

Raritan Bay.—First Inspection: A. M. Muckenfuss, G. D. White, R. L. Hallett, A. C. Holzapfel.

Second Inspection: A. M. Muckenfuss, G. D. White, R. L. Hallett.

Hampton Roads.—First Inspection: N. E. Adamson, R. L. Hallett, A. C. Holzapfel, Lieutenant P. R. Taylor (CC), U. S. N.

Second Inspection: A. M. Muckenfuss, N. E. Adamson, A. C. Holzapfel.

Beaufort, N. C.—First Inspection: H. A. Gardner, R. S. Perry, Jr.

Second Inspection: H. A. Gardner, R. S. Perry, Jr.

The condition of the paints was judged both as to preservation of the steel surface and the prevention of growths or accumulation of marine matter. The following grades were used:

Corrosion: Best grade, 10 (least corrosion); poorest grade, 0.

Fouling: Best grade, 10 (least fouling); poorest grade, 0.

RESULTS OF INSPECTION

In presenting the results on each panel exposed under sea water, the results on the paints applied to the backs of the panels are given in Table I. In presenting the results on the main tests on the fronts of the panels, the photographs of the second inspection at Raritan Bay are shown in Figs 1 to 16. Below each photograph is a diagram of the corresponding panel in the position in which it was submerged, showing the position of each paint.

The paints are in vertical strips, five paints to each panel. On each vertical strip, the anti-corrosive was first applied to the cleaned surface, followed by the anti-fouling composition, each coat drying one day, with the exception of red lead, which was permitted to dry four days.

TABLE I.—RATINGS AT INSPECTIONS OF PAINTS ON THE BACKS OF THE PANELS

Panel Number	Paint	First Inspection		Second Inspection	
		Corrosion	Fouling	Corrosion	Fouling
	RARITAN BAY				
16	**No. 35**	7	8	2	7
17	**No. 36**	8	7	3	1
18	**No. 42**	6	9	2	4
19	**No. 43**	8	9	4	6
20	**No. 49**	6	9	4	5
21	**No. 50**	7	9	6	5
22	No. 58 **anti-fouling** No. 59 **anti-corrosive**	9	9	7	8
23	No. 55 **anti-fouling** No. 26 **anti-corrosive**	8	8	6	7
24	**No. 61**	6	9	9	7
25	**No. 61**	7	9	7	8
26	**No. 61**	8	9	4	8
27	**No. 61**	8	9	8	10
28	**No. 61**	9	9	10	10
29	**No. 61**	8	9	9	10
30	**No. 61**	8	9	9	10
	HAMPTON ROADS				
1	..	7	8	9	8
2	..	6	8	7	7
3	..	9	9	9.5	9.5
4	..	9	8	9	8
5	..	10	8	10	5
6	..	10	8	10	6
7	..	8.5	7	8	9
8	..	9	7	8	7
10	..	2	8	0	8
12	..	9	10	9	10
13	..	3	10	9	1

On the vertical strips of the diagrams, the description of the paint and its grades on testing are printed according to the following scheme: The paint numbers are in boldface type. Immediately above this, in the upper portion of the vertical strips, are the grades for the inspections at Beaufort, N. C. Immediately below the paint numbers are the grades for the Hampton Roads inspections. In the bottom position of these vertical strips are to be found the grades of the Raritan Bay inspections.

In any group of (usually) four figures for the grades in the vertical strips, being the inspection in any one locality, the left figures represent the first inspection and the right figures, the second inspection. In these same groups, the upper figures are the inspections for corrosion and the lower figures (in italics) are for fouling.

ANTI-FOULING PAINTS USED

Between the last two groups of grades above described, there are placed symbols preceded by figures representing the percentage of toxic ingredient in the whole anti-fouling composition, the following symbols being used:

A, Copper, metallic, powder;
B, Copper Arsenate (aceto-arsenite);
C, Copper cyanide;
D, Copper oxide, electrolytic;
E, Mercury arsenate;
F, Mercury oxide, yellow;
G, Lead arsenate.

In Paints No. 62 and 63, the toxic ingredient was potassium hydroxide, added in the proportion of 1½ oz. to a gallon of paint.

In addition to the above toxic ingredients, enough of the following base pigment, proportioned as indicated, was added to bring toxic and pigment up to a total of 40 per cent of the whole paint:

Zinc oxide	24.3	per cent
Spanish red oxide	57.1	"
Asbestine	18.6	"

The anti-fouling vehicle was thus 60 per cent of the composition. One coat of it was applied, unless otherwise stated. In Paints Nos. 1 to 25 and 51 to 54, inclusive, this vehicle (Vehicle No. 1) consisted of:

Rosin	38	per cent
Ozokerite	2	"
Rubber	1	"
Stearic acid	6	"
Zinc oxide	3	"
Petroleum spirits	50	"

In Paints Nos. 26 to 50 and 63 to 67, inclusive, this vehicle (Vehicle No. 2) consisted of:

Crude mineral oil	5.85	per cent
Pale gloss oil	81.41	"
Benzol	6.46	"
Grinding japan	6.28	"

In Paints Nos. 55 to 58, inclusive, and No. 62, this vehicle (Vehicle No. 3) consisted of:

Alcohol	58.2 per cent
Gum shellac	19.7 "
Pine tar oil	11.4 "
Turpentine	10.7 "

The rest of the anti-fouling paints had special formulas, as follows:

Paint No. 59:

Pigment		55 per cent:
Paris green	56 per cent	
Chrome green	11 "	
Titanox	11 "	
Mercury bichloride	11 "	
Mercury oxide, yellow	11 "	
Vehicle		45 per cent (Vehicle No. 4):
Ester gum	45 per cent	
Benzol	45 "	
Spar varnish	10 "	

Paint No. 60 (containing Vehicle No. 5):

Rosin	7.33 per cent
Coal-tar naphtha	21.02 "
Coal tar	4.00 "
Rubber solution	3.41 "
Zinc resinate	18.18 "
Petroleum spirits	2.83 "
Zinc oxide	12.50 "
Indian red	12.50 "
Silica	8.00 "
Cuprous oxide (copper oxide, electrolytic)	10.23 "

Paints Nos. 61 and 69 (containing Vehicle No. 3):

Alcohol	36.78 per cent
Gum shellac	13.12 "
Pine tar oil	7.6 "
Turpentine	7.13 "
Zinc oxide	13.12 "
Indian red	13.12 "
Mercury oxide, yellow	7.13 "

Paint No. 68:

Pigment		40.6 per cent:
Ferric oxide	36.58 per cent	
Lithopone	14.64 "	
Cupric oxide (copper oxide, scale)	39.63 "	
Mercurous chloride	9.15 "	

Paint No. 68—*Continued*

Vehicle	59.4 per cent (vehicle No. 6):	
Raw linseed oil		4.85 per cent
Varnish		39.00 "
Pine tar		13.05 "
Creosote oil		12.85 "
Mineral oil and naphtha		30.25 "

Paints Nos. 72, 73, and 74:

At Raritan Bay—Same as Nos. 61 and 69 above.
At Beaufort, N. C.—No paints above No. 68.

Paint No. 249:

Crude mineral oil	21 lb.
Pale gloss oil	36 lb.
Benzol	3 gal.
Grinding japan	3 gal.

ANTI-CORROSIVE PAINTS USED

Unless otherwise stated, one coat of anti-corrosive paint was applied,—the first coat,—as follows:

Paints Nos. 1 to 25, inclusive (Anti-corrosive No. 1):

Iron oxide	20.0 per cent
Stearine pitch	12.0 "
Rubber	0.8 "
Gilsonite	12.0 "
Tar oil	55.2 "

Paints Nos. 26 to 50 and 63 to 67, inclusive (Anti-corrosive No. 2):

Pigment	66 per cent:	
Aluminum stearate		1 per cent
China clay		7 "
Iron oxide		75 "
Red lead		17 "
Vehicle	34 per cent:	
Linseed oil		12.1 per cent
Volatile materials		72.3 "
Gums and resinates		15.6 "
Vehicle	34 per cent:	
Rubbing varnish		20.0 per cent
Grinding japan		33.0 "
Mineral spirits		6.8 "
Benzol		9.2 "
Pale gloss oil		9.8 "
Light naphtha		21.2 "

Paints Nos. 51 to 58, inclusive (Anti-corrosive No. 3):

Red lead (98 per cent Pb_3O_4)	81 per cent
Raw linseed oil	18 "
Turpentine drier	1 "

Paints Nos. 59, 61, 62, and 69 (Anti-corrosive No. 4):

Alcohol	47.33 per cent
Gum shellac	7.62 "
Pine tar oil	4.57 "
Turpentine	4.28 "
Zinc dust	9.14 "
Zinc oxide	27.05 "

Paint No. 60 (Anti-corrosive No. 5):

Rosin	5.42 per cent
Rubber solution (6 oz. crude rubber in 1 gal. benzol)	2.71 "
Coal-tar naphtha	34.69 "
Coal tar	3.52 "
Manganese linoleate	11.93 "
Zinc resinate	7.05 "
Venetian red	8.67 "
Zinc oxide (XX American)	17.34 "
Talc	8.67 "

Paint No. 68 (Anti-corrosive No. 6):

Pigment		42.55 per cent:
Iron oxide	20.78 per cent	
Lithopone	29.0 "	
Carbon	0.26 "	
Asbestine	49.96 "	
Vehicle		57.45 per cent:
Varnish	78.45 per cent	
Creosote	10.0 "	
Kerosene	11.55 "	

Paints Nos. 72, 73, and 74 at Raritan Bay:
The same as Paints Nos. 59, 61, 62, and 69, above.

Paint No. 249:

Aluminum stearate	30 lb.
English china clay	200 lb.
60-per-cent brown oxide	800 lb.
Purple oxide	1400 lb.
Red lead	500 lb.
Rubbing varnish	300 lb.
Grinding japan	500 lb.
Petroleum spirits	100 lb.
Benzol	19 gal.
Pale gloss oil	19 gal.
Naphtha	50 gal.

Paints Nos. 75, 76, 77, and 78:

Two coats of Anti-corrosive No. 4.

Paints Nos. 79 and 80 (Anti-corrosive No. 7):

Benzol	18.8	per cent
Spar varnish	2.7	“
Plasticized benzol	12.1	“
(Benzol containing 5 per cent of crude rubber)		
Ester gum	21.9	“
Dry zinc dust	12.1	“
Dry zinc oxide	32.4	“

Anti-Fouling Compositions for Paints Nos. 75 to 80, Inclusive

(Paints Nos. 75 to 78, inclusive, have approximately Vehicle No. 3)

Paint No. 75:

Navy red shellac	45.1	per cent
Alcohol	19.4	“
Indian red	4.9	“
Zinc oxide	13.8	“
Mercury oxide, yellow	7.9	“
Pine tar oil	8.9	“

Paint No. 76:

Navy red shellac	41.7	per cent
Alcohol	17.9	“
Indian red	4.6	“
Zinc oxide	12.8	“
Mercury oxide, yellow	7.3	“
Turpentine	7.6	“
Pine tar oil	8.2	“

Paint No. 77:

Navy yellow shellac	47.2	per cent
Alcohol	19.3	“
Indian red	2.9	“
Zinc oxide	13.7	“
Mercury oxide, yellow	8.2	“
Pine tar oil	8.8	“

Paint No. 78:

Navy yellow shellac	47.1	per cent
Alcohol	19.3	“
Indian red	2.9	“
Zinc oxide	13.7	“
Turpentine	8.2	“
Pine tar oil	8.8	“

Paint No. 79 (Vehicle No. 7):

Benzol	19.2 per cent
Spar varnish	2.8 "
Plasticized benzol	12.4 "
Ester gum	22.3 "
Dry zinc oxide	16.5 "
Dry Indian red	16.5 "
Dry mercury oxide, yellow	3.4 "
Dry copper oxide, electrolytic	6.9 "

Paint No. 80 (Vehicle No. 7):

Benzol	19.8 per cent
Spar varnish	2.8 "
Plasticized benzol	12.6 "
Ester gum	22.8 "
Dry Paris green	15.8 "
Dry chrome green	3.5 "
Dry zinc oxide	17.5 "
Dry mercury oxide, yellow	5.3 "

SPECIAL PAINTS USED AT HAMPTON ROADS

Paint No. 63:

One coat of Anti-corrosive No. 2 and one coat of the Anti-fouling described below for the back of Panel No. 10.

Paint No. 69:

The same as Paint No. 69 at Raritan Bay.

Paint No. 72:

This was given one coat of the vehicle below and portland cement dusted on before the varnish set. An application was then made of a mixture of the vehicle and yellow mercury oxide. This painting may be reported as follows:

Anti-corrosive (No. 8):

Pigment		30 per cent:
Portland cement	100 per cent	
Vehicle		70 per cent:
Rosin	53.8 per cent	
Coal tar naphtha	39.8 "	
Special pine tar oil	6.4 "	

Anti-fouling (Vehicle No. 8):

Pigment		10 per cent:
Mercury oxide, yellow	100 per cent	
Vehicle		90 per cent:
Same as anti-corrosive above		

Paint No. 73:

This was painted with one coat of the vehicle given below placed on the back of Panel No. 13, and portland cement was dusted on before the varnish set. When dry, the surface was again coated with the same varnish. (No toxic pigment was used.) The paint may be described as follows:

Pigment		26 per cent:
Portland cement	100 per cent	
Vehicle		74 per cent (Vehicle No 9):
Rosin	23.2 per cent	
Spar varnish	44.2 "	
Benzol	32.6 "	

Paint No. 74:

This was painted in the same way as described under Paint No. 72 above, except that 1.5 lb. of electrolytic copper oxide was used in the second coat instead of 1 lb. of mercury oxide. This substitution changes the anti-fouling to

Pigment	13.9 per cent
Vehicle	86.1 "

BACKS OF THE PANELS AT HAMPTON ROADS

Panel No. 1:

Two coats of Anti-corrosive and one coat of Anti-fouling:

Anti-corrosive (No. 9):

Pigment		37 per cent:
Zinc oxide	75.2 per cent	
Zinc dust	24.8 "	
Vehicle		63 per cent:
Yacca gum	11.4 per cent	
Alcohol	73.9 "	
Pine tar oil	6.7 "	
Turpentine	8.0 "	

Anti-fouling (Vehicle No. 10):

Pigment		32.1 per cent:
Zinc oxide	39.3 per cent	
Indian red	39.3 "	
Mercury oxide, yellow	21.4 "	
Vehicle		67.9 per cent:
Yacca gum	19 per cent	
Alcohol	59 "	
Turpentine	10 "	
Pine tar oil	12 "	

Panel No. 2:

One coat each of Anti-corrosive and of Anti-fouling, the same paints as used on the back of Panel No. 1.

Panel No. 3:

Two coats of Anti-corrosive Paint No. 4 and one coat of Anti-fouling paint, the same as Paint No. 69.

Panel No. 4:

One coat of Anti-corrosive Paint No. 4 and one coat of Anti-fouling paint, the same as Paint No. 69.

Panel No. 5:

Two coats of Anti-corrosive and one coat of Anti-fouling paint: Anti-corrosive (No. 10):

Pigment		44.5 per cent:
Zinc oxide	73 per cent	
Zinc dust	27 "	
Vehicle		55.5 per cent:
Ester gum	39.7 per cent	
Benzol	55.7 "	
Spar varnish	4.6 "	

Anti-fouling (Vehicle No. 11):

Pigment		43 per cent:
Indian red	39.4 per cent	
Zinc oxide	39.4 "	
Mercury oxide, yellow	19.6 "	
Mercury bichloride	1.6 "	
Vehicle		57 per cent:
Ester gum	39.7 per cent	
Benzol	55.7 "	
Spar varnish	4.6 "	

Panel No. 6:

One coat each of Anti-corrosive and Anti-fouling, the same paints as used on the back of Panel No. 5:

Panel No. 7:

Two coats of Anti-corrosive Paint No. 4 and one coat of Anti-fouling paint as below (Vehicle No. 12):

Pigment		26 per cent:
Charcoal	22.4 per cent	
Zinc oxide	44.4 "	
Mercury oxide, yellow	33.2 "	

Vehicle		74 per cent:
Yacca gum	24.7 per cent	
Alcohol	63.3 "	
Special pine tar oil	6.2 "	
Turpentine	5.8 "	

Panel No. 8:

Two coats of the following paint (Vehicle No. 13):

Pigment		47.5 per cent:
Zinc oxide	22.2 per cent	
Silica	22.2 "	
Blanc fixe	22.2 "	
Paris green	11.1 "	
Mercury oxide, yellow	7.5 "	
Zinc dust	14.8 "	
Vehicle		52.5 per cent:
Yacca gum	26.7 per cent	
Alcohol	58.7 "	
Special pine tar oil	8.6 "	
Petroleum spirits	6.0 "	

Panel No. 10:

Two coats of the following paint (Vehicle No. 14):

Pigment		41 per cent:
Titanox	22.28 per cent	
Zinc oxide	22.8 "	
Copper oxide, electrolytic	22.8 "	
Mercury oxide, yellow	8.8 "	
Zinc dust	22.8 "	
Vehicle		59 per cent:
Rosin	33.4 per cent	
Alcohol	54.5 "	
Special pine tar oil	12.1 "	

Panel No. 12:

A spirit varnish was applied and pigment dusted on before the varnish set. This was approximately equivalent to using the following (Vehicle No. 15):

Pigment		35 per cent:
Portland cement	80 per cent	
Mercury oxide, yellow	20 "	
Vehicle		65 per cent:
Rosin	53.8 per cent	
Coal tar naphtha	39.8 "	
Special pine tar oil	6.4 "	

Panel No. 13:

A varnish was applied and portland cement dusted on before the varnish had set. No toxic pigment was applied. The composition was equivalent to the following (Vehicle No. 16):

Pigment		26 per cent:
Portland cement	100 per cent	
Vehicle		74 per cent:
Rosin	23.2 per cent	
Spar varnish	44.2 "	
Benzol	32.6 "	

RESULTS

As in the report of the sub-committee for 1922, so also this year, the results are tabulated without detailed comment. Further on in the prosecution of this investigation, the subject of standards, based on detailed results, will be considered.

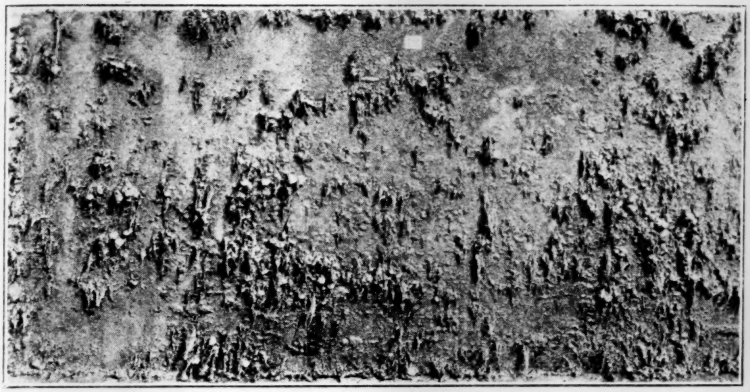
Of the anti-corrosive paints tested out during the past two years, three seem to give about equally good results and appear superior to the others. These are the rubbing varnish-petroleum solvent-red oxide of iron type (Anti-Corrosive No. 2) and the shellac-alcohol-zinc dust type (Anti-Corrosive No. 4), which dry in a few hours, and the red lead-linseed oil type (Anti-Corrosive No. 3), which requires three or four days to dry. Of the anti-fouling vehicles, the pale gloss oil-mineral oil type (Vehicle No. 2), and the shellac-alcohol type (Vehicle No. 3) have shown the best grades. Several other combinations have given excellent results this year with one or two paints. While mercury oxide seems to be the best single pigment, combinations of mercury oxide and copper oxide appear to be better than mercury oxide alone.

In making any interpretation of the results of the tests at Beaufort, N. C., it is necessary to bear in mind that the panels were not exposed until September and that they were not exposed to test during the period of heaviest fouling. Therefore, though fouling is by no means a negligible factor at Beaufort during the fall and winter, more importance is attached to the factors of corrosion and film condition. A large majority of the test panels there gave very poor service, the most noticeable point of failure being corrosion, though in a number of cases failure was due to blistering and falling away of the paint film.

Realizing that the panel stage of testing is not finally conclusive, the sub-committee has already initiated a third series of tests to be reported upon a year hence. These include the painting of four U. S. Shipping Board vessels on diagonally opposite quarters in contrast with the Board's standard paint on the other two quarters, and the application of patches near the stern from the water line to keel on about twenty merchant vessels and on seven naval vessels. In all, 116 different paint combinations will be used, including five anti-corrosives, five anti-fouling vehicles, and eight combinations of toxic ingredients—all satisfactory according to our panel tests of the past two years.

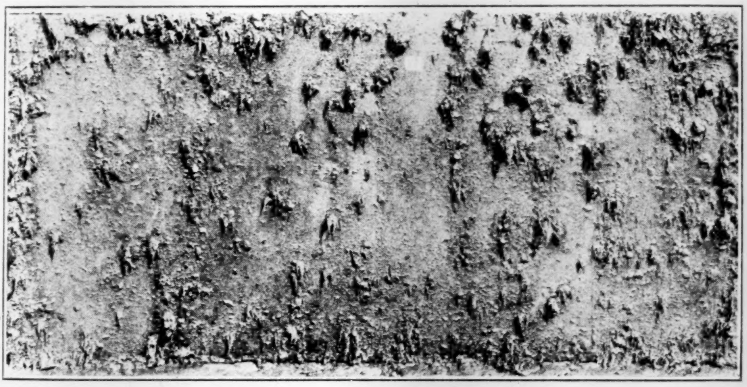
Respectfully submitted on behalf of the sub-committee,

A. M. MUCKENFUSS,
Chairman.



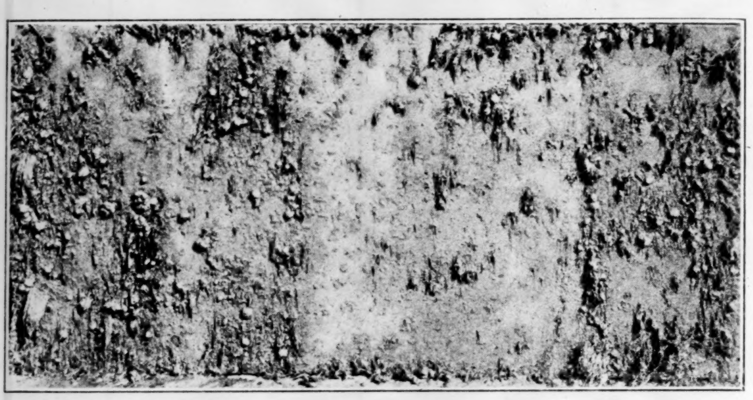
1 6	1 5	0 2	0 3	0 5	0 5	0 5	0 5	1 9	0 3
No. 1		**No. 2**		**No. 3**		**No. 4**		**No 5**	
5 9	3 5	5 9	2 8	5 9	2 7	5 9	3 7	5 9	1 5
12 *D*		24 *D*		6 *F*		10 *F*		5 *B* 6 *D*	
6 9	3 3	6 9	1 3	6 8	2 3	6 8	2 3	6 9	2 3

FIG. 1.—Panel No. 16. Photograph of Raritan Bay Panel, Second Inspection.



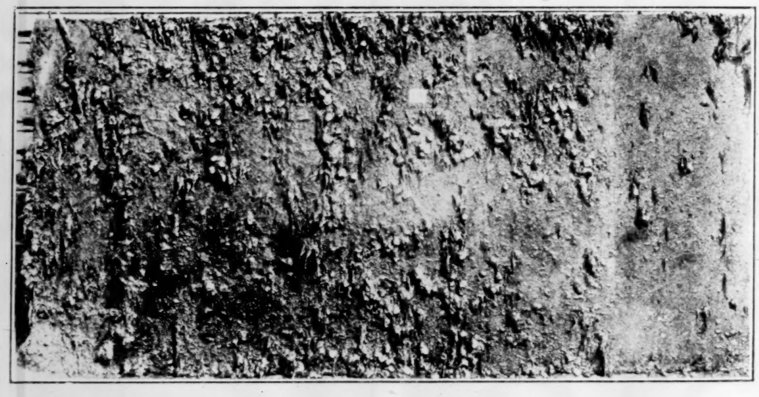
0 6	0 3	1 6	0 5	1 6	0 5	1 6	0 5	2 5	0 5
No. 6		**No. 7**		**No. 8**		**No. 9**		**No. 10**	
5 9	1 9	7 9	2 9	8 8	3 9	7 9	2 9	4 9	1 9
5 *B* 4 *F*		6 *D* 4 *F*		6 *D* 4 *E*		6 *A* 4 *F*		6 *C* 4 *F*	
5 9	5 7	5 9	5 7	5 9	5 7	5 9	5 7	5 9	5 7

FIG. 2.—Panel No. 17. Photograph of Raritan Bay Panel, Second Inspection.



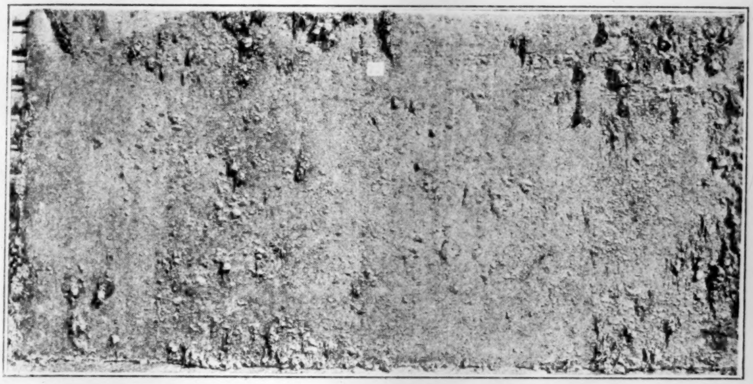
No. 11		No. 12		No. 13		No. 14		No. 15	
1	2	0	0	0	0	0	0	0	0
3	*1*	*3*	*5*	*3*	*3*	*6*	*3*	*6*	*3*
5	1	5	1	4	1	7	2	6	1
8	*6*	*8*	*6*	*8*	*7*	*8*	*8*	*8*	*7*
6 *C* 4 *E*		10 *B* 6 *D*		10 *B* 4 *F*		12 *D* 4 *F*		12 *D* 4 *E*	
5	3	5	3	5	3	5	4	5	3
9	*4*	*9*	*4*	*9*	*8*	*9*	*7*	*9*	*4*

FIG. 3.—Panel No. 18. Photograph of Raritan Bay Panel, Second Inspection.



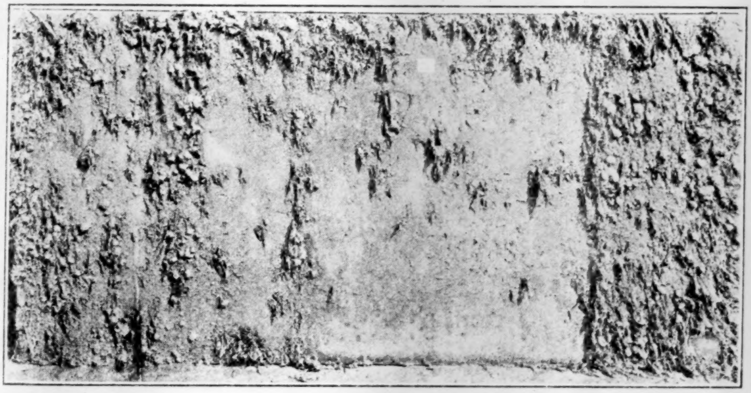
No. 16		No. 17		No. 18		No. 19		No 20	
0	0	0	0	0	0	0	0	0	0
6	*3*	*3*	*3*	*3*	*5*	*3*	*5*	*3*	*3*
9	4	8	2	7	0	8	1	7	2
9	*9*	*9*	*9*	*9*	*7*	*9*	*6*	*9*	*7*
12 *A* 4 *F*		12 *C* 4 *F*		12 *C* 4 *E*		5 *B* 12 *D*		5 *B* 8 *F*	
3	2	3	2	3	2	4	3	5	4
9	*6*	*9*	*6*	*9*	*5*	*9*	*6*	*9*	*8*

FIG. 4.—Panel No. 19. Photograph of Raritan Bay Panel, Second Inspection.



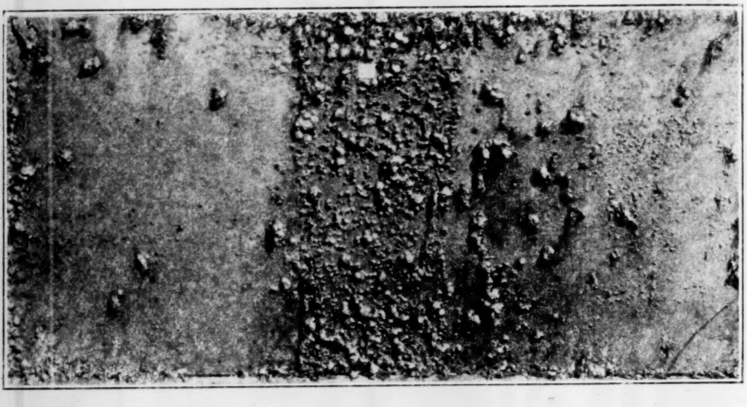
8 *9*	9 *9*	8 *9*	7 *5*	0 *5*	0 *5*	0 *5*	0 *3*	1 *9*	0 *0*
No. 21		**No. 22**		**No. 23**		**No. 24**		**No. 25**	
9 *10*	2 *8*	7 *9*	1 *8*	7 *9*	1 *8*	9 *9*	1 *8*	7 *7*	1 *7*
6 *D* 8 *F*		6 *D* 8 *E*		5 *A* 8 *F*		6 *C* 8 *F*		6 *C* 8 *E*	
5 *9*	4 *8*	5 *9*	3 *7*	5 *9*	4 *8*	5 *9*	4 *8*	5 *9*	2 *6*

FIG. 5.—Panel No. 20. Photograph of Raritan Bay Panel, Second Inspection.



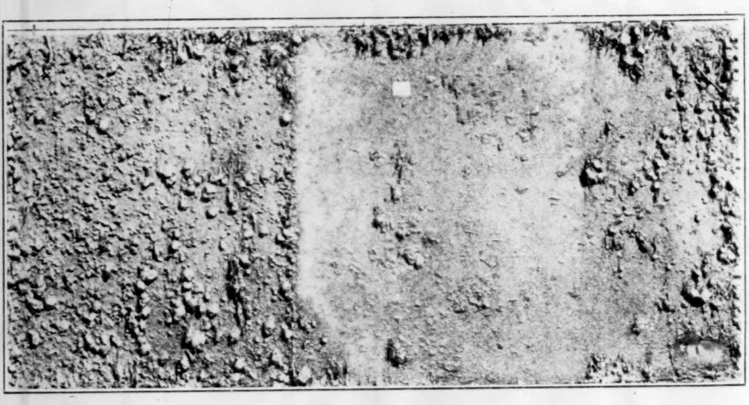
8 *0*	9 *9*	8 *0*	7 *8*	8 *7*	4 *8*	8 *7*	7 *10*	6 *0*	5 *5*
No. 26		No. 27		No. 28		No. 29		No. 30	
9 *10*	7 *8*	7 *9*	1 *4*	7 *9*	8 *9*	9 *9*	8 *9*	7 *7*	1 *4*
12 *D*		24 *D*		6 *F*		10 *F*		5 *B* 6 *D*	
7 *9*	5 *4*	7 *9*	8 *5*	7 *9*	7 *7*	7 *9*	6 *7*	7 *9*	3 *2*

FIG. 6.—Panel No. 21. Photograph of Raritan Bay Panel, Second Inspection.



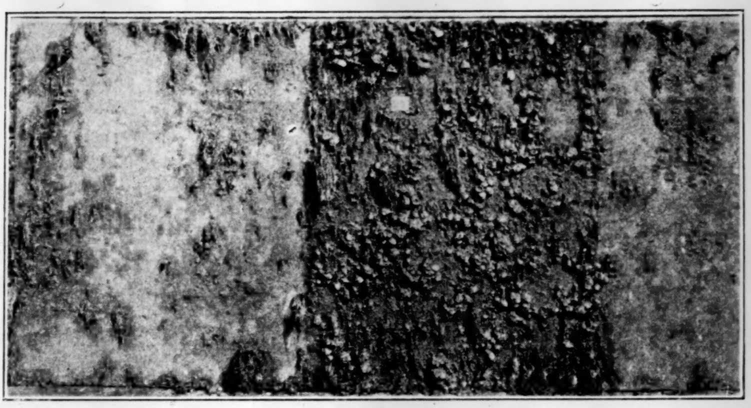
7	9	8	4	8	10	8	7	8	5
3	*9*	*6*	*8*	*5*	*8*	*5*	*10*	*5*	*5*
No. 31		**No. 32**		**No. 33**		**No. 34**		**No. 35**	
7	4	10	8	8	1	9	8	9.5	8
9	*7*	*9*	*9*	*7*	*8*	*9*	*9*	*9*	*9*
5 *B* 4 *F*		6 *D* 4 *F*		6 *D* 4 *E*		6 *A* 4 *F*		6 *C* 4 *F*	
9	9	8	7	10	8	9	8	7	6
8	*8*	*9*	*8*	*5*	*1*	*7*	*4*	*9*	*7*

FIG. 7.—Panel No. 22. Photograph of Raritan Bay Panel, Second Inspection.



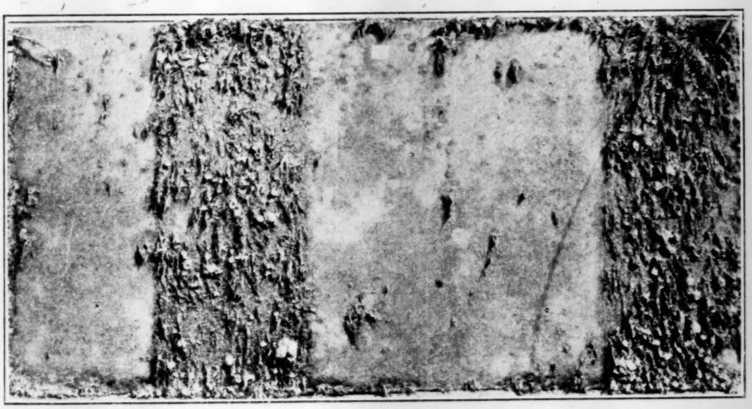
8	5	—	—	2	4	4	4	7	7
6	*4*	—	—	*3*	*0*	*3*	*0*	*5*	*9*
No. 36		**No. 37**		**No. 38**		**No. 39**		**No. 40**	
8	1	6	1	7	1	9	4	8	1
8	*9*	*7*	*7*	*8*	*6*	*9*	*9*	*8*	*6*
6 *C* 4 *E*		10 *B* 6 *D*		10 *B* 4 *F*		12 *D* 4 *F*		12 *D* 4 *E*	
5	6	6	7	6	5	6	4	7	4
5	*1*	*7*	*2*	*8*	*9*	*10*	*10*	*10*	*6*

FIG. 8.—Panel No. 23. Photograph of Raritan Bay Panel, Second Inspection.



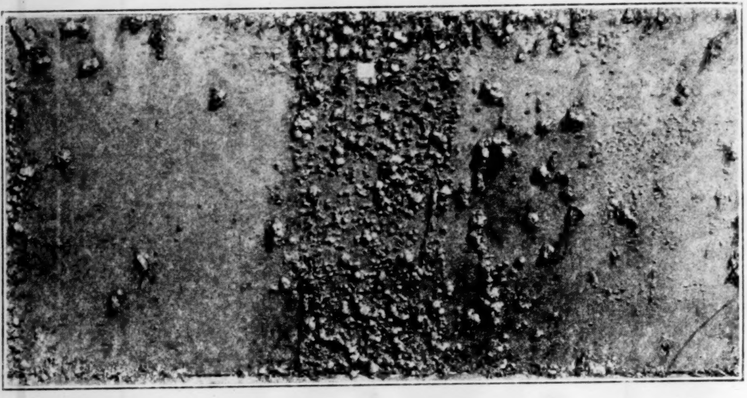
8 *8*	4 *8*	8 *8*	5 *9*	7 *5*	5 *4*	7 *5*	5 *1*	7 *5*	4 *8*
No. 41		**No. 42**		**No. 43**		**No. 44**		**No. 45**	
10 *9*	8 *9*	7 8	7 8	9 *8*	4 *8*	9 *7*	3 *6*	9 *8*	7 *8*
12 *A* 4 *F*		12 *C* 4 *F*		12 *C* 4 *E*		5 *B* 12 *D*		5 *B* 8 *F*	
8 *9*	8 *6*	8 *9*	7 *5*	9 *9*	7 *2*	9 *7*	8 *2*	8 *9*	6 *7*

FIG. 9.—Panel No. 24. Photograph of Raritan Bay Panel, Second Inspection.



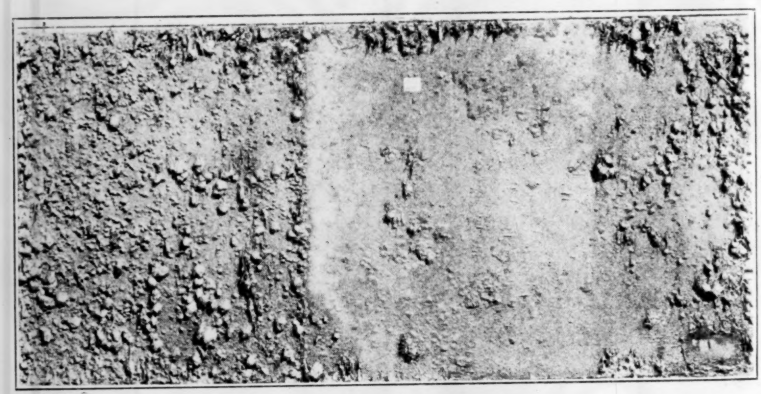
5 *5*	4 *8*	7 *5*	10 *8*	7 *5*	10 *8*	4 *8*	4 *8*	8 *8*	4 *8*
No. 46		**No. 47**		**No. 48**		**No. 49**		**No. 50**	
10 *8*	9 *9*	10 *9*	9 *9*	10 *9*	9 *8*	9 *9*	8 *8*	9 *8*	9 *9*
6 *D* 8 *F*		6 *D* 8 *E*		5 *A* 8 *F*		6 *C* 8 *F*		6 *C* 8 *E*	
8 *9*	8 *9*	7 *9*	8 *3*	8 *9*	8 *9*	8 *9*	8 *9*	8 *8*	7 *3*

FIG. 10.—Panel No. 25. Photograph of Raritan Bay Panel, Second Inspection.



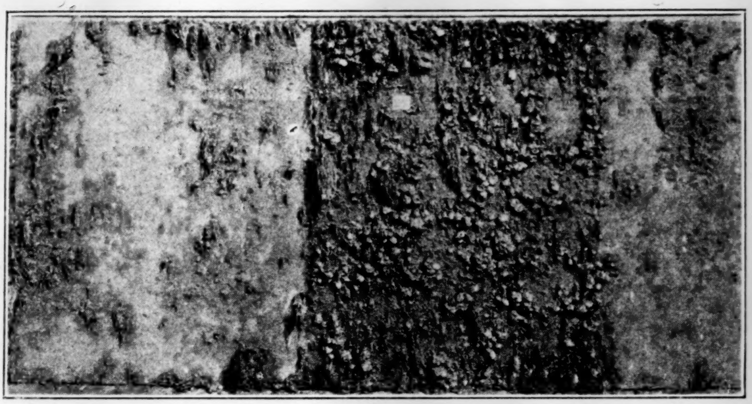
7 *3*	9 *9*	8 *6*	4 *8*	8 *5*	10 *8*	8 *5*	7 *10*	8 *5*	5 *5*
No. 31		**No. 32**		**No. 33**		**No. 34**		**No. 35**	
7 *9*	4 *7*	10 *9*	8 *9*	8 *7*	1 *8*	9 *9*	8 *9*	9 5 *9*	8 *9*
5 *B* 4 *F*		6 *D* 4 *F*		6 *D* 4 *E*		6 *A* 4 *F*		6 *C* 4 *F*	
9 *8*	9 *8*	8 *9*	7 *8*	10 *5*	8 *1*	9 *7*	8 *4*	7 *9*	6 *7*

FIG. 7.—Panel No. 22. Photograph of Raritan Bay Panel, Second Inspection.



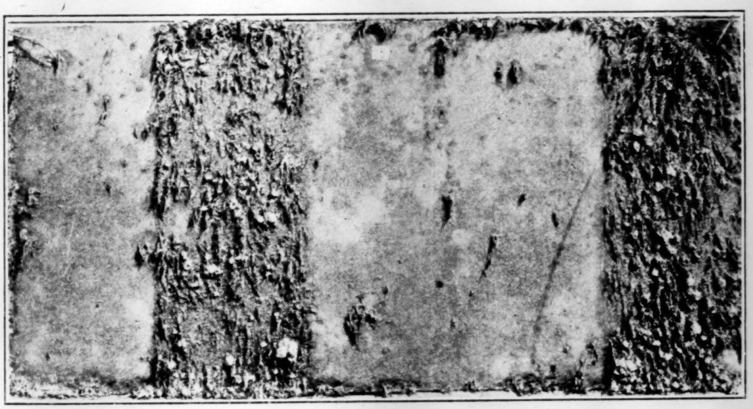
8 *6*	5 *4*	— —	— —	2 *3*	4 *0*	4 *3*	4 *0*	7 *5*	7 *9*
No. 36		**No. 37**		**No. 38**		**No. 39**		**No. 40**	
8 *8*	1 *9*	6 *7*	1 *7*	7 *8*	1 *6*	9 *9*	4 *9*	8 *8*	1 *6*
6 *C* 4 *E*		10 *B* 6 *D*		10 *B* 4 *F*		12 *D* 4 *F*		12 *D* 4 *E*	
5 *5*	6 *1*	6 *7*	7 *2*	6 *8*	5 *9*	6 *10*	4 *10*	7 *10*	4 *6*

FIG. 8.—Panel No. 23. Photograph of Raritan Bay Panel, Second Inspection.



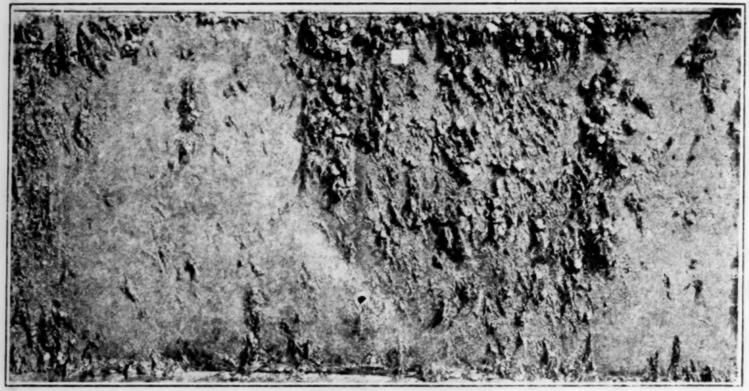
8	4	8	5	7	5	7	5	7	4
8	*8*	*8*	*9*	*5*	*4*	*5*	*1*	*5*	*8*
No. 41		**No. 42**		**No. 43**		**No. 44**		**No. 45**	
10	8	7	7	9	4	9	3	9	7
9	*9*	*8*	*8*	*8*	*8*	*7*	*6*	*8*	*8*
12 *A* 4 *F*		12 *C* 4 *F*		12 *C* 4 *E*		5 *B* 12 *D*		5 *B* 8 *F*	
8	8	8	7	9	7	9	8	8	6
9	*6*	*9*	*5*	*9*	*2*	*7*	*2*	*9*	*7*

FIG. 9.—Panel No. 24. Photograph of Raritan Bay Panel, Second Inspection.



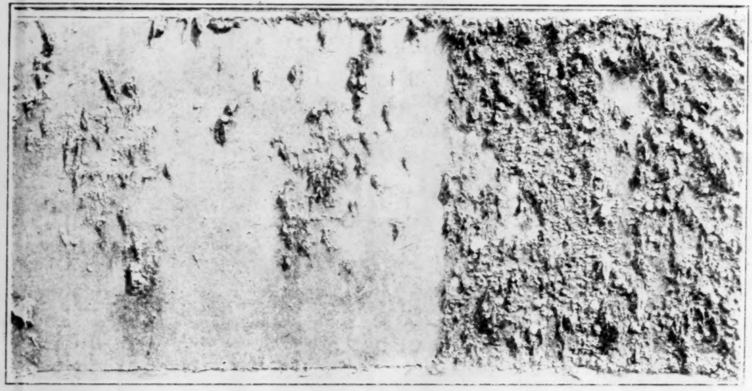
5	4	7	10	7	10	4	4	8	4
5	*8*	*5*	*8*	*5*	*8*	*8*	*8*	*8*	*8*
No. 46		**No. 47**		**No. 48**		**No. 49**		**No. 50**	
10	9	10	9	10	9	9	8	9	9
8	*9*	*9*	*9*	*9*	*8*	*9*	*8*	*8*	*9*
6 *D* 8 *F*		6 *D* 8 *E*		5 *A* 8 *F*		6 *C* 8 *F*		6 *C* 8 *E*	
8	8	7	8	8	8	8	8	8	7
9	*9*	*9*	*3*	*9*	*9*	*9*	*9*	*8*	*3*

FIG. 10.—Panel No. 25. Photograph of Raritan Bay Panel, Second Inspection.



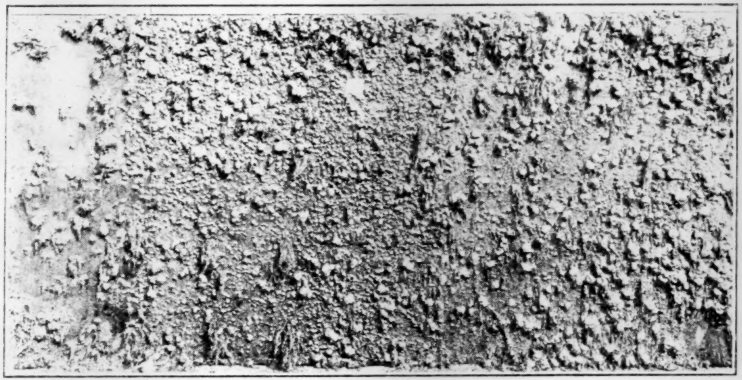
2 0 *6* *0*	2 0 *3* *9*	8 7 *6* *9*	8 9 *3* *9*	8 10 *4* *5*
No. 51	**No. 52**	**No. 53**	**No. 54**	**No. 55**
— — — —	— — — —	— — — —	— — — —	— — — —
12 *D*	8 *F*	5 *B* 4 *F*	6 *C* 4 *F*	12 *D*
9 8 *10* *5*	8 9 *8* *6*	8 9 *9* *3*	8 9 *9* *3*	8 9 *7* *5*

FIG. 11.—Panel No. 26. Photograph of Raritan Bay Panel, Second Inspection.



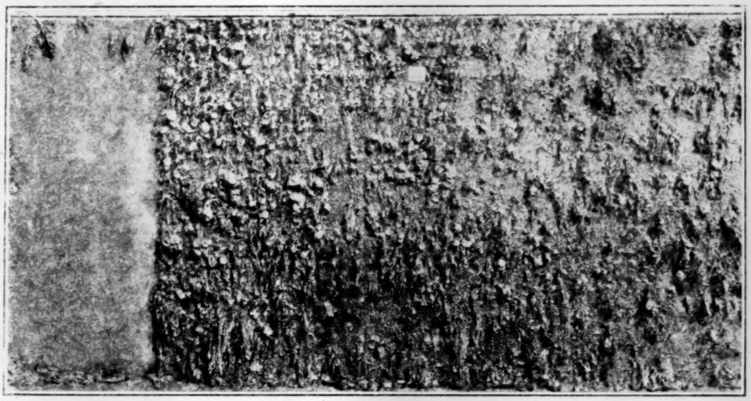
1 2 *6* *6*	3 2 *3* *6*	8 7 *6* *9*	10 10 *4* *8*	5 5 *0* *1*
No. 56	**No. 57**	**No. 58**	**No. 59**	**No. 60**
8 6 *9* *7*	8 7 *9* *8*	7 7 *9* *8*	10 8 *9* *7*	8 3 *8* *4*
8 *F*	5 *B* 4 *F*	6 *C* 4 *F*	(See text)	(See text
5 7 *9* *7*	7 9 *9* *8*	6 8 *9* *7*	10 7 *6* *1*	8 6 *8* *2*

FIG. 12.—Panel No. 27. Photograph of Raritan Bay Panel, Second Inspection.



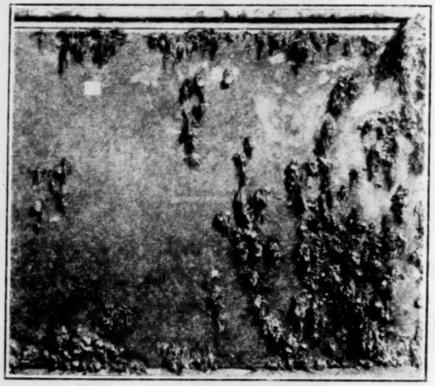
5	4	9	10	—	—	5	5	5	5
10	*8*	*5*	*1*	—	—	*5*	*1*	*5*	*1*
No. 61		**No. 62**		**No. 63**		**No. 64**		**No. 65**	
9	7	5	1	7	3	8	8	8	6
9	*9*	*8*	*8*	*8*	*5*	*9*	*8*	*8*	*6*
(See text)		(See text)		(See text)		6 *D* 4 *G*		6 *C* 4 *G*	
8	9	7	9	8	7	9	9	9	9
7	*5*	*6*	*1*	*5*	*1*	*9*	*2*	*8*	*2*

Fig. 13.—Panel No. 28. Photograph of Raritan Bay Panel, Second Inspection.



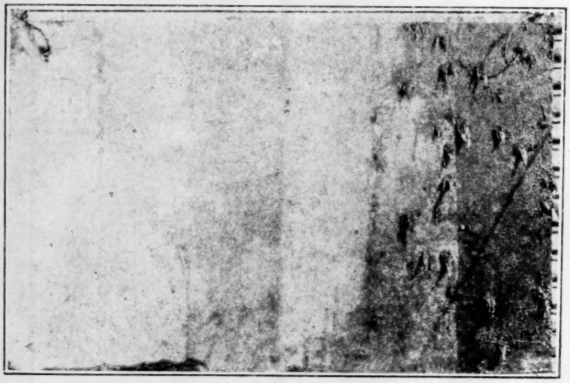
8	7	8	7	8	7	2	1	—	—
9	*10*	*9*	*5*	*5*	*5*	*5*	*1*	—	—
No. 66		**No. 67**		**No. 249**		**No. 68**		**No. 69**	
8	8	8	4	8	8	7	6	6	7
9	*9*	*7*	*6*	*9*	*9*	*7*	*5*	*7*	*6*
8 *F* 5 *G*		5 *E* 5 *G*		(See text)		(See text)		(See text)	
8	8	7	9	8	8	5	5	3	4
9	*10*	*9*	*1*	*10*	*2*	*7*	*2*	*9*	*3*

Fig. 14.—Panel No. 29. Photograph of Raritan Bay Panel, Second Inspection.



— — — —	— — — —	— — — —
No. 72	**No. 73**	**No. 74**
10 8 *8* *9*	10 10 *6* *7*	10 10 *8* *10*
(See text)	(See text)	(See text)
8 10 *8* *7*	8 10 *8* *7*	8 10 *8* *7*

FIG. 15.—Panel No. 30. Photograph of Raritan Bay Panel, Second Inspection.



— — — —	— — — —	— — — —	— — — —	— — — —	— — — —
No. 75	**No. 76**	**No. 77**	**No. 78**	**No. 79**	**No. 80**
— 7 — *10*	— 6 — *10*	— 7 — *10*	— 7 — *10*	— 10 — *8*	— 10 — *7*
(See text)	(See text)	(See text)	(See text)	(See text)	(See text)
— 6 — *10*	— 6 — *10*	— 6 — *10*	— 6 — *10*	— 10 — *7*	— 10 — *7*

FIG. 16.—Panel No. 33. Photograph of Raritan Bay Panel, Second Inspection.

NOTE.—This panel was submerged August 17, later than those represented in the other foregoing photographs. The same paints were submerged at Hampton Roads early in September.

REPORT OF COMMITTEE D-2

ON

PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 has held three meetings during the past year. The committee now has a voting membership of 61, consisting of 29 producers and 32 non-producers. During the year additional sub-committees have been appointed as follows:

Sub-Committee XIX on Illuminating Oils;
Sub-Committee XX on Nomenclature;
Sub-Committee XXI on Crude Petroleum;
Sub-Committee XXII on Natural Gas Gasoline.

The committee, during the past year, through its Sub-Committee XIV on Water and Sediment has, together with Committees D-4 on Road and Paving Materials, D-7 on Timber and D-8 on Waterproofing Materials, cooperated with Committee E-1 on Methods of Testing in the preparation of a method for the determination of water both in petroleum products and other bituminous materials. This method is being presented for publication as tentative, and is appended hereto.[1] The committee accordingly recommends that, contingent upon the acceptance by the Society of this tentative method, the present Tentative Method of Test for Water in Petroleum Products (D 95 – 21 T)[2] be withdrawn.

The following A.S.T.M. methods are used by the U. S. Government in the routine testing and inspection of petroleum products which are bought under Federal specifications, and were adopted on October 31, 1922, by the Federal Specifications Board, superseding similar methods issued in former publications of the Government. The Government, in adopting these testing methods, gratefully acknowledges its indebtedness for the cooperation of the American Society for Testing Materials.

Government Method Number	Title	A.S.T.M. Method Serial Designation
20.11	Cloud and Pour Tests	D 97 – 22 T
30.11	Viscosity of Lubricating Oils	D 47 – 22 T
30.2	Viscosity of Fuel Oils at 122° F	D 88 – 21 T

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[1] See p. 694.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 666 (1921).

GOVERNMENT METHOD NUMBER	TITLE	A.S.T.M. METHOD SERIAL DESIGNATION
40.1	Melting Point of Paraffin Wax	D 87 – 22
40.3	Melting Point of Petrolatum	D 127 – 22 T
110.1	Flash Point of Volatile Flammable Liquids by Tag Closed Tester	D 56 – 21
110.21	Flash Point by Means of the Pensky-Martens Closed Tester	D 93 – 22
110.3	Open Cup Flash and Fire Test	D 92 – 21 T
300.1	Water	D 95 – 21 T
300.3	Water and Sediment by Centrifuge	D 96 – 21 T
310.1	Precipitation Number	D 91 – 21 T
410.1	Breakdown Test	D 48 – 17 T and D 117 – 21 T
500.1	Carbon Residue	D 47 – 21
510.3	Free Acid	D 47 – 21
520.1	Sulfur in Burning Oils	D 90 – 21 T
520.21	Sulfur in Fuel Oil	D 129 – 22 T
530.21	Corrosion Test at 122° F	D 130 – 22 T
540.1	Saponification Number	D 94 – 21 T

Mr. Alexander Duckham, chairman of the Standardization Committee of the Institution of Petroleum Technologists of London, England, on his recent visit to America, brought to the attention of the secretary of Committee D-2 the work which the Standardization Committee is doing in adopting testing methods for petroleum products and the desire of this committee to cooperate with the American Society for Testing Materials. Mr. A. E. Dunstan, in his paper read before the Institution of Petroleum Technologists in October, 1922, on the "Standardization of the Testing of Petroleum" included the statement, "It will be noticed that many of the methods of the American Society for Testing Materials have been adopted." Mr. Duckham in his communication addressed to the secretary of Committee D-2, December 2, 1922, emphasizes the "debt which the Standardization Committee of the Institution of Petroleum Technologists, indeed the whole of the petroleum fraternity, owes to the A.S.T.M. for the splendid work which it has done in standardization, and for its broad-minded generosity in so willingly imparting its results to all who express an interest in its work."

It is the intention of the Institution of Petroleum Technologists to issue in one brochure a collection of *standard* methods, and not *tentative* methods, for the Institution feels that the use of any such word as tentative would weaken the confidence of the users. However, attention will be called to the fact that though the tests are the best at present available, they will be revised from time to time.

RECOMMENDATIONS IN REFERENCE TO TENTATIVE STANDARDS

Committee D-2 recommends for publication as tentative, a Method of Test for Color of Lubricating Oils by Means of Union Colorimeter; and a Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer. These methods are appended to the report of Sub-Committee VI on Color.[1]

The committee recommends certain minor revisions in the specifications for thermometers contained in Methods D 86 – 21 T, and the elimination of cotton from the thermometer bulb. These recommendations are contained in the report of Sub-Committee VIII on Distillation. It further recommends that this method, with revision, be continued as tentative.

The committee is presenting for publication as tentative, a Method for Steam Emulsion Test. This method is appended to the report of Sub-Committee XI on Emulsification.[2]

TABLE I

Item	Affirmative	Negative	Not Voting
PROPOSED NEW TENTATIVE STANDARDS			
Proposed Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials	43	1	2
Proposed Tentative Method of Test for Color of Lubricating Oils by Means of Union Colorimeter	37	0	9
Proposed Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer	36	1	9
Tentative Method of Test for Steam Emulsion of Lubricating Oils	37	3	6
Proposed Tentative Methods of Testing Gas Oils	31	3	12
PROPOSED REVISIONS OF EXISTING TENTATIVE STANDARDS			
Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (D 86 – 21 T)	37	6	3
Method of Test for Flash and Fire Points by Means of Open Cup (D 92 – 21 T)	40	2	4
Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 22 T)	39	1	6
WITHDRAWAL OF TENTATIVE STANDARD			
Withdrawal of Tentative Method of Test for Water in Petroleum Products (D 95 – 21 T)	43	1	2

The committee recommends certain revisions in the present Method for Flash and Fire Points by Means of Open Cup (D 92 – 21 T) including a change in the plate upon which the cup rests. The revisions are contained in the report of Sub-Committee XII on Flash. The committee recommends that with these revisions the method be continued as tentative.

The committee recommends certain slight revisions in the Test for Cloud and Pour Points of Petroleum Products (D 97 – 22 T). These revisions are given in the report of Sub-Committee XVI on Cloud and Pour Test. The committee further recommends that with these revisions the method be continued as tentative.

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[1] See pp. 677–684.—ED.

[2] See p. 685.—ED.

The committee is presenting for publication as tentative, Methods of Testing Gas Oils, appended hereto,[1] as prepared by Sub-Committee XVIII on Gas Oils in cooperation with the American Gas Association.

Appended hereto are reports of Sub-Committees I, IV, VI, VIII, X, XI, XII, XIII, XV, XVI, XIX, and XX.

The methods of test recommended for submission as tentative standards and the recommended revisions of present tentative standards have been submitted to letter ballot of the committee, which consists of 62 members; 46 ballots have been returned, and 16 members have refrained from voting. The results of the letter ballot are given in Table I.

This report has been submitted to letter ballot of the committee, which consists of 62 members, of whom 33 have voted affirmatively, none negatively, and 13 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. P. VAN GUNDY,
Chairman.

VAN H. MANNING,
Secretary.

K. G. MACKENZIE,
Vice Chairman.

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[1] See p. 703.—ED.

For Addendum to this report, see page 392.

REPORT OF SUB-COMMITTEE I ON PETROLATUM

Subsequent to the report of the sub-committee last year, three further samples for the determination of melting point of petrolatum were sent out, two of them mixtures made up on the lines of Sample *D* experimented with last year. These were submitted to the members of the sub-committee, and the results reported are given in Table I.

TABLE I.—RESULTS OF INVESTIGATION ON MELTING POINT OF PETROLATUM

Laboratory	Petrolatum	Melting Point					Thermometer, deg. Fahr.
		First Test	Second Test	Third Test	Fourth Test	Average	
No. 1	5	109.5	108.5	109.2	.....	109.1	A.S.T.M. 3½-in. immersion bulb 28 mm. in length, 5 to 6 mm. in diameter
	6	122.0	121.5	122.7	.....	122.1	
	7	131.8	130.2	130.6	.....	130.9	
No. 2	5	110.2	109.5	109.3	.....	109.7	A.S.T.M.
	6	121.0	122.5	120.7	.....	121.4	
	7	130.0	129.5	130.7	.....	130.1	
No. 3	5	115.6	117.2	110.0	110.4	113.3	A.S.T.M.
	6	120.8	121.4	120.2	.....	120.8	
	7	130.6	130.2	130.8	.....	130.5	
No. 4	5	114.0	114.5	114.0	114.0	114.0	Bulb 20 mm. in length, 6 mm. in diameter
	6	126.0	126.0	127.0	127.0	126.5	
	7	134.0	134.0	134.0	134.0	134.0	
No. 5	5	111.3	111.5	111.3	.....	111.3	A.S.T.M.
	6	119.8	119.9	120.8	119.4	119.9	
	7	130.6	130.5	130.5	.....	130.5	
No. 6	5	114.5	113.9	115.0	.....	114.5	Petrolatum Thermometer. Glass Extension
	6	122.3	123.6	124.5	.....	123.5	
	7	132.7	133.6	131.8	.....	132.7	
	5	116.0	114.7	114.0	.....	114.9	A.S.T.M.
	6	125.2	122.8	124.1	.....	124.0	
	7	132.9	134.0	132.8	.....	133.2	
No. 7	5	118.8	118.6	117.5	.....	118.3	A.S.T.M.
	6	122.9	122.9	121.1	.....	122.3	
	7	120.7	121.7	123.4	.....	121.9	

Sample No. 5 was a mixture of Sample No. 7 and a filtered cylinder oil of poor pour test in percentages of 70 of the latter and 30 of the petrolatum. Sample No. 6 contained equal percentages of the same cylinder stock and the same petrolatum. Sample No. 7 was a straight petrolatum.

The greatest range of results was reported on the mixture of the lowest melting point, and this by operators who are accustomed to work with petroleum products. The difference between the highest and the lowest reported by different operators was 10.3° F., one operator having shown a range of 7.2° F. from highest to lowest.

The results on the sample having the highest melting points are close enough to confirm the feeling that the method of measuring the melting point used, namely, the Tentative Method of Test for Melting Point of Petrolatum (D 127 - 22 T) is at least as good as any that had been previously proposed, and that it is valuable enough to be continued as tentative pending further suggestions.

One member of the sub-committee carried out a number of tests to determine the effect of successive melting and cooling of the same sample of petrolatum. The results were wide apart, but that such remeltings do have an effect on the melting point was shown by another operator who made ten determinations, giving readings from 110 to 117.2° F. and caused him to suggest that "this sample seems to have more of the characteristics of a very high cold-test cylinder stock than of petrolatum." Where the melting point of petrolatum is low, it may be desirable to specify that this characteristic be obtained on successive portions of the sample under examination rather than on remeltings of the same sample.

Some experiments have been made with the Organ grease tester for determining the hardness of petrolatum, but not enough results to warrant presenting a report.

The color of lighter colored petrolatums may be measured in melted condition, either in the $\frac{1}{4}$-in. cell with Lovibond glasses or in solution in kerosene or other water white solvent.

Respectfully submitted on behalf of the sub-committee,

FLORUS R. BAXTER,
Chairman.

REPORT OF SUB-COMMITTEE IV ON GREASE

The change in chairmanship of the sub-committee caused some delay in getting under way with the year's work, but at the meeting held in St. Louis in conjunction with the meeting of Committee D-2 it was agreed that:

1. The most pressing problem was the development of a satisfactory consistency test for grease.

2. In developing such a test, attention should first be focused on Nos. 1 to 5 cup greases.

3. It would probably be better to test the grease in its original consistency without any working.

4. All members should send the chairman details of any tests which they deemed worthy of consideration, and the chairman should endeavor to select the most promising.

After considering the various possibilities and suggestions, it appears that the most promising scheme in sight for testing cup greases is the use of a cone "penetrometer," made by modifying the New York Testing Laboratory asphalt penetrometor by the substitution of a slightly truncated 45-deg. cone, $1\frac{1}{2}$ in. wide at the top, for the needle used in that instrument.

The details of the cone as recommended are shown in Fig. 1. It may conveniently be made from aluminum and brought to a weight of 52.5 g., so that when inserted in the 100-g. asphalt plunger minus the 2.5-g. needle, the total weight will be the desired figure of 150 g. The stem should preferably be made of brass.

The recommended procedure for the test is to place the penetrometer over a substantially smooth level surface of the grease (which may have been cut, but not worked or subjected to pressure) in a 1-lb. can or larger container. The temperature should be within 1° F. of 77° F. The cone is then lowered until the tip just touches the surface of the grease, the scale set, and the plunger released for five seconds. The penetration is read in tenths of a millimeter by the same procedure as is customary in the case of asphalt tests.

Preliminary work with the test as above described appears to justify the following tentative conclusions:

1. The test is quite satisfactory for greases Nos. 2 to 5, inclusive, though there is some question as to No. 1—in the case of the softer samples the penetration is around 400 (4 cm.) and only one test can

be made in a 1-lb. can without danger of having the results influenced by the sides of the can or the previous depression. The test can be made more satisfactory for No. 1 grease by using only 100 g. total weight, but this gives rather too low penetrations, and too high average deviations for the more important No. 4 and No. 5 greases. Very probably, modified methods will have to be developed for No. 0 and No. 1 greases.

2. The motion of the plunger is practically complete within the five seconds specified.

3. Careful cutting away of a layer of grease does not appreciably affect the results on the remainder.

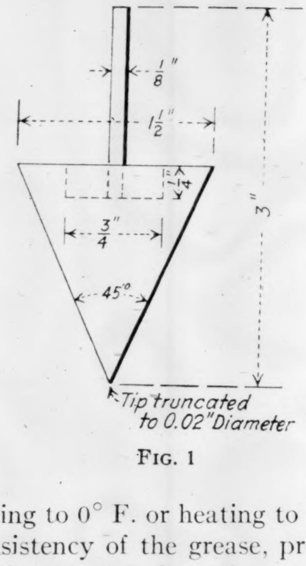

FIG. 1

4. Previous cooling to 0° F. or heating to 100° F. does not appreciably affect the consistency of the grease, provided it is brought to 77° F. throughout before the test is made.

5. Variations in the temperature of the test cause the penetrations to vary roughly 0.5 per cent per 1° F.

6. It is impracticable to make and keep a perfectly sharp point on the cone, and it has therefore been found necessary to truncate the tip to 0.02 in. (0.5 mm.) diameter. The use of a monel or other hard metal tip seems desirable in order to prevent rounding off of the tip.

7. The following table indicates the consistencies of one series of grease samples, together with the average deviation between the individual observations on a single sample. Sufficient data has not as yet been obtained to determine whether or not these consistencies

are typical. They will, of course, vary considerably from sample to sample.

GREASE No.	PENETRATION	AVERAGE DEVIATION	AVERAGE DEVIATION, PER CENT
1	380	3.8	1.0
2	270	3.0	1.1
3	190	2.8	1.5
4	90	2.5	2.8
5	60	2.1	3.5

Thorough working has but little effect on No. 1 grease, but as the hardness of the grease increases, the effect of working grows greater and greater, until for No. 4 and No. 5 greases the penetration is more than twice that for the unworked sample.

8. In taking samples from a large container without working or otherwise affecting the properties of the grease, a reasonably satisfactory method is to punch several holes in the bottom of a No. 1 sample can (or smaller for the harder greases), force the can top down into the grease until it is substantially full, and cut off the grease at the top of the can by using a curved knife. The surface is later cut off level with an ordinar yknife. Care must be taken that the whole mass of grease does not move when the plunger is released.

All the members of the committee have agreed to cooperate in trying out this method, first on their own product or purchases, and after submitting suggestions for changes in the method, to try out the test as modified on a series of samples sent out from a central laboratory. The possibility of making the test on worked samples is also to be considered further.

Respectfully submitted on behalf of the sub-committee,

ROBERT E. WILSON,
Chairman.

REPORT OF SUB-COMMITTEE VI ON COLOR

Sub-Committee VI on Color has continued its study of color standards and methods for the petroleum industry, so that more uniform and logical determinations may be made to meet present refinery and sales requirements.

Type of Instruments.—After careful consideration and experimentation, it is found advisable to confine attention to the two instruments now in general use, the Saybolt Chromometer for light oils and the N. P. A. Colors (Union Colorimeter) for lubricating oils. Both of these instruments have been modified—improvements having been made that will enhance their field of usefulness. They have been found to be the most practical instruments for plant and commercial use.

Artificial Light.—Continued and increasing demand for closer differentiation and determination of color for all grades of oil has made it imperative that a better and more stable and uniform source of light be devised than the use of ordinary daylight. The sub-committee has been experimenting with various forms of artificial light with marked success, and believes that the final results will meet with general approval.

Saybolt Chromometer (Refined Oils).—The manufacturer of this instrument has already made a number of improvements in line with the suggestions contained in the 1922 report of the sub-committee. Additional refinements are recommended, for example, the use of a black metal diaphragm with a central aperture 12 mm. in diameter, to be placed in the bottom of the color standard tube. This will equalize the apparent light conditions observed on the walls of the tubes. Also a metal diaphragm cap for each tube should be used, the purpose of which is threefold: the protection of the tube ends when adjusting the same in position; centralizing the position of the tubes under the optical unit, and covering the top edges of the tubes, thus eliminating the possibility of the colored edge, occasionally appearing, from coming in line with the optical field.

It is important that certain limitations be made in specifications for the glass tubes—both color standard and oil tubes. It has been found that the greatly varying internal diameters observed in many tubes have been responsible for errors and disputes. The limitations should be between 14 and 16 mm. in internal diameter. It has been observed that the present range of internal diameter varies from 13 mm. to 19 mm.

Uniform and easier readings, under all conditions, can be obtained by use of an artificial daylight lamp, emitting a well diffused light. This would eliminate a source of trouble, heretofore encountered, due to differing light conditions, such as sky, clouds and introduction of color from foreign objects.

Experimental work has shown that the prisms in the optical head must be of matched size in angles and areas, and so mounted as to preclude the possibility of disarrangement.

N. P. A. Colors (Union Colorimeter) Lubricating Oils.—From a commercial point of view and plant convenience, the Union Colorimeter has been found satisfactory, and with the recent modifications and improvements made by the Union Petroleum Co., its usefulness has been greatly enhanced. The color standards have been extended in scale to read by half numbers from No. 1 to No. 5 and then by full numbers to No. 8, inclusive. This extended range of scale broadens the use of the instruments. Cylinder oils can be read as heretofore with the *A*, *D* and *E* color standards or can be more closely read on the regular scale from No. 1 to No. 8, still retaining the specified (15/85) dilution.

With the divisions and subdivisions, as noted, provided by fixed glass standards, further divisions can be obtained by preparation of 4-oz. sample bottles of oil, making $\frac{1}{4}$ numbers in the lower scale and $\frac{1}{2}$ numbers (and $\frac{1}{4}$ numbers if desired) in the upper scale, by mixing 50 per cent of one oil of a standard color with 50 per cent of the next higher or lower standard color, the result reading half way between the two and numbered accordingly. In this manner a complete sample case can be made with a color number range from 0 to No. 8 by quarter numbers.

To lessen the liability of dispute in reading color through the uncertain 4-oz. bottle, a uniform size of cylinder has been provided for use in case of doubt and with these a reading at a uniform depth of oil can be made.

With the extended scale of color, a more constant lighting is necessary to read the deeper oil color. There has been provided for use with this instrument a form of daylight lamp, similar to that devised for the Saybolt Chromometer, and in this way a source of light is obtained that is practically constant in intensity and color value.

In conclusion, it may be well to note that the changes and additions suggested do not radically change the methods that have become more or less universal but refine the present methods to conform to the advanced demands in the petroleum industry.

The sub-committee presents, for publication as tentative, proposed tentative methods for color reading of refined oils by use of the Saybolt Chromometer and for reading of lubricating oils by use of the Union Colorimeter, as appended hereto.[1]

The sub-committee wishes to acknowledge with deep thanks the work of T. D. Simpson of the Union Petroleum Co. and J. T. Kavanagh of The Atlantic Refining Co. for the very thoughtful and intense effort that they have devoted to this subject.

Respectfully submitted on behalf of the sub-committee,

IRVIN K. GILES,
Chairman.

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[1] See pp. 677–684.—ED.

REPORT OF SUB-COMMITTEE VIII ON DISTILLATION

The following revisions are recommended in the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 – 21 T).[1]

Section 6 (a).—In the requirement for distance of limiting graduations from the bottom of bulb and top of stem, make the following changes by the insertion of the italicized figures and the omission of the figures in brackets:

> "The distance to [30] *32*° F. or 0° C. line from bottom of bulb: 100 to 110 mm.
>
> "Distance to [580] *572*° F. or 300° C. line from top of stem: 30 to 45 mm."

Section 6 (b).—In the requirement for distance of limiting graduations from the bottom of bulb and top of stem, make the following changes by the insertion of the italicized figures and the omission of the figures in brackets:

> "Distance to [30] *32*° F. or 0° C. line from bottom of bulb: 25 to 35 mm.
>
> "Distance to [760] *752*° F. or 400° C. line from top of stem: 30 to 45 mm."

Section 8.—Omit Paragraph (*c*) reading as follows, re-lettering the subsequent paragraphs accordingly:

> "(*c*) The bulb of the distillation thermometer shall be covered uniformly with a long-fiber absorbent cotton weighing not less than 3 nor more than 5 mg. A fresh portion of clean cotton shall be used for each distillation."

It is recommended that the method as revised be continued as tentative.

The sub-committee also considered changing from the present total immersion thermometers to the partial immersion type. There was unanimous objection to changing to partial immersion thermometers. The question of changing the specifications for the shield was discussed at length but no change is recommended.

Respectfully submitted on behalf of the sub-committee,

ERNEST W. DEAN,
Chairman.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 631 (1921).

REPORT OF SUB-COMMITTEE X ON OXIDATION AT HIGH TEMPERATURES

The sub-committee has transacted no business during the past year owing to a lack of concrete suggestion of apparatus other than those of an admittedly tentative nature. The chairman had hoped to be able to present a tentative apparatus and method giving at least reproducible results. This has not been possible.

The problem has been worked on steadily during the past year at the U. S. Bureau of Standards with the support of the Engineering Division of the Army Air Service. Three different air baths have been constructed and tried out. It was found that the temperature gradients in these baths were very large, 15 to 20° C., and that oil temperatures in test flasks and beakers, both of which were tried, were not reproducible from run to run, nor were temperatures in symmetrically located vessels the same.

The best of these air baths was rather expensive and complicated, involving the use of a high-speed fan (2500 r.p.m.) in the bath with the difficulties inherent in high-speed bearings at high temperatures (250° C.). The excessive varnish formation when using the air baths was also thought undesirable.

Preliminary runs on a crude hot plate enclosed in a metal shield yielded more consistent results than had yet been attained, and in view of these results a more elaborate enclosed hot plate providing for natural draft ventilation was constructed along lines similar, except for the addition of a surrounding shield, to the oven for which G. A. Kramer of the Shell Oil Co., of California, reported rather satisfactory results. Work has been carried on with this oven using the same oil as in previous work. Agreement of results of different samples of this oil, both for the same and different runs, have not, in general, been wholly satisfactory, but indications are that conditions for satisfactory operation may be realized.

Runs have been made with both 50-cc. flasks and 50-cc. beakers, and it has been found necessary to grind the bottoms of the vessels used to obtain good thermal contact with the hot plate. The thickness of the bottoms of the vessels has been correlated with the values for residue. No varnish is formed.

For given conditions, flasks show about one-half the residue of beakers with about one-fiftieth of the evaporation loss. Evaporation losses for a given run can be correlated though not exactly nor always with residue.

To date, the most promising results have been obtained with 50-cc. flasks for 2 hours at 250° C. However, it is not at all certain that better results may not eventually be obtained by the use of beakers.

The results of six sets of runs each on six samples of the same oil are given in the following table to indicate the general nature of the more recent results:

50-cc. Beakers					50-cc. Flasks			
	Run No. 1	Run No. 2		Run No. 3		Run No. 1	Run No. 2	Run No. 3
Beaker *X*	0.77	1.05	Beaker No. 7*a*	0.76	Flask *A*	0.40	0.45	0.49
Beaker *W*	0.68	1.03	Beaker No. 8	0.68	Flask *B*	0.41	0.37	0.42
Beaker *P*	0.60	0.85	Beaker No. 11	0.86	Flask *C*	0.43	0.42	0.46
Beaker No. 2	0.71	1.05	Beaker *J*	1.01	Flask *D*	0.42	0.46	0.52
Beaker No. 3	0.55	0.84	Beaker *R*	0.66	Flask *E*	0.36	0.45	0.52
Beaker No. 12	0.72	1.03	Beaker *V*	0.76	Flask *F*	0.43	0.50	0.47
Average	0.67	0.98	Average	0.79	Average	0.41	0.44	0.48

Beaker Run No. 1, 2 hours at 250° C., beakers rotated reduced ventilation.
Beaker Run No. 2, 2 hours at 250° C., beakers rotated increased ventilation.
Beaker Run No. 3, 2 hours at 250° C., beakers rotated.
Flask Run No. 1, 2 hours at 250° C., flasks stationary.
Flask Run No. 2, 2 hours at 250° C., flasks rotated.
Flask Run No. 3, 2 hours at 250° C., flasks stationary.

About forty runs of six samples each have been made with the new enclosed hot plate. All work has been done on a single oil sample and consistency of results has been the preliminary aim. In the course of the year over 1500 samples of oil have been oxidized.

Work is being continued to determine optimum conditions for reproducible results. Some of the factors being investigated are the effect of form of vessel, thickness and area of the bottom of the vessel, variations in ventilation, and methods of automatically integrating temperature and ventilation effects in a given run by motion of vessels relative to the hot plate and shield during the run.

The temperatures of the oil are observed by a thermometer in an oil vessel symmetrically located with respect to the test vessels and with the hot plate this temperature is 20 to 30° C. below the plate temperature. This difference varies with different operating conditions and manual control of temperatures has been found most feasible and very satisfactory. It seems probable that automatic control would have few, if any, advantages for routine test work, especially where a number of ovens are banked.

It seems that the most promising solution of the development of an oxidation test method may consist in the use of a manually controlled enclosed hot plate with natural draft ventilation and vessels of specified form and dimensions.

Respectfully submitted on behalf of the sub-committee,

W. S. JAMES,
Chairman.

REPORT OF SUB-COMMITTEE XI ON EMULSIFICATION

The investigations of the sub-committee during the past year have been along three lines as follows:

1. Work on the R. E. Test,
2. Investigation of other methods,
3. Fundamental study of emulsions.

In the 1922 report of Committee D-2, reference was made to the R. E. Test as serving for a suitable basis for adoption by the committee with the proviso that further work was needed, first, toward simplification of the test, and second, toward developing the test in such a way as to differentiate more accurately between oils which possessed doubtful emulsion characteristics.

Experimental work in the Tide Water laboratories with regard to changes in the R. E. Test has led to the following suggestions:

1. The elimination of a definite temperature, namely, 67° F., for the emulsifying bath, and substituting for this a range of temperature, namely, 67 to 78° F.

2. The elimination of the requirement for maintaining the temperature of the sample while steaming at 190 to 195° F.

Five oils were sent to members of the sub-committee in order to determine whether the above-mentioned suggestions were practicable or not. Replies have been received from seven of the fourteen members.

RESULTS OF R. E. TESTS WITH MODIFICATIONS 1 AND 2

LABORATORY	SAMPLE No. 1	SAMPLE No. 2	SAMPLE No. 3	SAMPLE No. 4	SAMPLE No. 5
No. 1	1.5	4.5	2.0	0.5	3.0
No. 2	1.5	4.9	2.0	0.25	2.5
No. 3	1.0	4.3	1.5	0.25	2.5
No. 4	0.5	5.5	2.0	0.5	3.0
No. 5	1.5	5.5	2.3	0.5	3.7
No. 6	1.5	5.2	2.2	0.5	3.0
No. 7	1.5	5.5	2.0	0.5	3.0
No. 8	1.5	6.5	2.0	0.5	3.3

Reference to the above table indicates fairly good concordance between the different laboratories reporting, even though the range of oils is not quite as wide as might be desired.

In general, there was very good agreement among the members of the sub-committee in regard to the R. E. Test obtained on the five oils submitted. This indicates, first, that the R. E. Test can be satisfactorily duplicated, and second, that the modifications 1 and 2 above mentioned, regarding temperature control, are entirely feasible.

It is recommended that the R. E. Test as appended hereto[1] be published as a tentative standard.

The addition of a special demulsifying agent, such as oleic acid, in order to distinguish between oils of doubtful qualtity was considered by the sub-committee. Results have been obtained with regard to both the R. E. number and the B. E. number (signifying tentatively "breaking of emulsion as measured by time required to completely break the emulsion when oleic acid is added") on thirty different oils, and a table is given below showing the possibility of differentiating between oils which ordinarily would be given an R. E. number of 20 plus, by means of a B. E. number as determined with oleic acid. Further work will undoubtedly be necessary by members of the committee on this point. It has been found possible to check satisfactorily the B. E. number on two samples of oil submitted to the Tide Water laboratories by a member of the committee, thereby indicating the possibility of duplicating results in different laboratories. Preliminary data has also been obtained on the B. E. modification showing that it is possible to classify by this method separate batches of the same oil which have been subjected to different degrees of refinement.

It has not been found feasible to add oleic acid directly to the oil before the steaming process, consequently its use has been limited to oils which possess an R. E. number greater than 20, adding it after the R E. number has been determined.

The effect of the volume of oleic acid on the time of settling has been determined and the following table illustrates the time of settling as a function of the volume of oleic acid used:

AMOUNT OLEIC ACID USED, CC.	TIME OF SETTLING, SECONDS
1.0	9.0
2.0	7.5
3.0	6.0
5.0	5.5
7.0	4.5
10.0	4.0
15.0	4.0

When plotted, this indicates a gradual decrease in time of settling with the increase in volume of oleic acid used. A minimum time of settling is noted for amounts of oleic acid corresponding to 10 cc. or more. This indicates that the use of 10 cc., as previously recommended, will produce the greatest effect in classifying the emulsion within a given time.

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[1] See p. 685.—ED.

In order to prove conclusively that the B. E. modification with oleic acid classifies oils which the R. E. Test fails to classify, and also to determine the possibility of the B. E. Test classifying oils with an R. E. number less than 20, more samples were obtained and R. E. numbers and B. E. numbers determined on these oils. In all, thirty-two oils were examined in this manner, determining first the regular R. E. number and then continuing the test, adding oleic acid according to the modifications suggested, recording the time necessary for complete breaking of the residual emulsion by the oleic acid. The oils used represent samples selected from different sources and cover different crudes, as well as finished stocks used for different types of lubrication.

TABLE I.—B. E. NUMBER WITH OLEIC ACID FOR OILS OF R. E. NUMBER LESS THAN 20

OIL	R. E. NUMBER (WITH MODIFICATIONS 1 AND 2), MINUTES	B. E. NUMBER WITH OLEIC ACID, MINUTES
No. 1	0.5	0.5
No. 2	0.5	0.5
No. 3	1.5	0.5
No. 4	2.0	0.5
No. 5	3.0	0.5
No. 6	3.5	0.5
No. 7	4.6	0.5
No. 8	5.5	1.0
No. 9	5.5	0.5
No. 10	5.5	1.0
No. 11	6.5	0.5
No. 12	7.0	0.5
No. 13	7.0	0.5
No. 14	8.5	1.0
No. 15	9.0	1.0
No. 16	13.0	0.5
No. 17	15.0	1.5
No. 18	15.0	2.0
No. 19	19.0	2.5
No. 20	19.0	1.5
No. 21	20.0	2.0

Reference to the above table indicates that in the case of oils with an R. E. number less than 20 there is a small but definite B. E. number obtained with oleic acid. This is due to the fact that even though there is a fairly clear line of demarcation between oil and water layers there is nevertheless a small amount of lacy cuff existing in the water layer which is completely broken by the addition of oleic acid. The results recorded in Table I indicate that for oils of this class the R. E. number is more sensitive than the B. E. number, therefore there is no need for the addition of oleic acid in such cases.

Table II.—B. E. Number for Oils With R. E. Number Greater Than 20

Oil.	R. E. Number (With Modifications 1 and 2), Minutes	B. E. Number With Oleic Acid, Minutes
No. 1	20 plus	2.5
No. 2	20 "	2.5
No. 3	20 "	2.5
No. 4	20 "	3.0
No. 5	20 "	3.5
No. 6	20 "	4.0
No. 7	20 "	4.5
No. 8	20 "	6.0
No. 9	20 "	6.5
No. 10	20 "	10.0
No. 11	20 "	15.0

Reference to the above table indicates clearly that it is possible to classify accurately oils which ordinarily would be given an R. E. number of 20 plus by the addition of oleic acid. It will be noted that there is a regular increase from oil No. 1 to oil No. 11 in the time of settling with oleic acid, and from the known characteristics of these oils those in the latter half of the table possess worse emulsification characteristics than those in the upper half. If the R. E. Test alone were used, such differences would not be indicated at all. For the purpose of final recording of the result of the emulsion test, it is suggested that a combination of the time for the R. E. and for the B. E. be given; for example, in the case of oil No. 1 in Table II, the resultant composite number would be 22.5, whereas in oil No. 10 it would be 30.0. In other words, instead of reporting separate R. E. and B. E. numbers which might be confusing, one final number representing the summation of both could be indicated, it being understood, naturally, that any total emulsification number greater than 20 would include a B. E. determined with oleic acid.

Experimental work was conducted to determine whether the length of time or intensity of shaking would influence the B. E. number. Results on an oil used for this purpose indicated that the time of shaking could be varied from two or three seconds (corresponding to that mentioned in the original modification) to 50 seconds, with a change in B. E. number of only from 6.0 to 6.5. It appears, therefore, that the variations in B. E. number due to this factor are negligible and that the intensity of shaking has no appreciable effect on the time of settling. This is undoubtedly due to the very effective action of oleic acid on oils which have been partially demulsified, especially at a temperature of 200° F.

The sub-committee was undecided in its views in regard to the differentiation of doubtful oils and it was recommended that further work be conducted by the sub-committee regarding the feasibility of using oleic acid in connection with the R. E. Test.

In addition to the above recommendation for the continuance of the work in regard to the use of oleic acid in connection with the R. E. Test, work on the development of other methods will be conducted, such as the Mechanical Shaker Test that is recommended by a representative of one of the oil companies, and the Surface Tension Test as given in the Appendix to this report.

Respectfully submitted on behalf of the sub-committee,

J. T-B. BOWLES,
Chairman.

APPENDIX

METHOD OF MEASURING THE EMULSIFYING TENDENCY OF LUBRICATING OILS, BASED ON SURFACE TENSION

By Howard Dimmig

Introduction

The extent to which an oil forms permanent emulsions with water or such aqueous solutions as are met in practice, is unquestionably proportional to the surface tension at the interface oil-water, or oil-aqueous solution. This surface tension is in like manner a true measure of the emulsifying tendency of the oil, or in other words, the ability of the oil to resist the formation of emulsions and to separate readily if an emulsion is formed.

A modification of the drop-weight method of surface tension measurement has been developed in the Research Laboratory of the Texas Co. and has been found so satisfactory that it is now used to determine the slightest differences in the nature of lubricating oils from the standpoint of their resistance to emulsion formation, and as a check against the Navy, R. E., and Conradson steaming tests. Consequently, it has seemed reasonable that such a method, properly standardized, would serve as the basis for a universal method of testing this property of lubricating oils. The details and factors influencing the standardization have been studied and the method proposed is given in this paper.

Nature of Test

The relative surface tensions of the oil at the interface with water and with 0.01 N aqueous sodium hydroxide solution are measured by noting the exact number of drops formed by a determined volume of the oil issuing from the tip of a calibrated pipette immersed in these liquids. The drop size expressed in cubic centimeters per 100 drops is thus determined.

The drop size determined under the proper conditions is directly proportional to and is a measure of the surface tension at the interface under examination. The absolute surface tension could, of course, be determined for each oil, but for the purpose of this work the relative surface tension will suffice and will be of equal significance.

It would be possible to establish for each class of oils (oils of the same viscosity) the minimum drop size allowable for a satisfactory product and any oils of the given class falling below this limit would, therefore, not be suitable while the oils forming the larger drop would be the more desirable. Because of numerous variables discussed later in this paper (such as viscosity, gravity, temperature, pipette-orifice diameter, etc.) this is not the preferred method of classification. Therefore, the ratio of the drop size in 0.01 N caustic to the drop size in distilled water is recommended, as this expression tends to cancel the effect of these variables. This is expressed as:

$$K = \frac{\text{cc. per 100 drops in 0.01 } N \text{ caustic}}{\text{cc. per 100 drops in distilled water}}$$

APPARATUS

The apparatus is a modification of Donnan's pippette.[1] . Fig. 1 shows the apparatus as used in the laboratory and as recommended for this test.

It consists of a calibrated drop-weight pipette, *a*, fixed on the mount *b*. The pipette is graduated near the 1-cc. and the 2-cc. mark. The internal diameter of the tubing of these points should be approximately 2 mm. so that 0.1 cc. in volume is represented by approximately 30.0 mm. of length. Every 0.1 cc. is divided into 10 parts and can easily be estimated to 0.0025 cc. The accuracy of the pipette could naturally be increased by decreasing the diameter of the pipette in these portions, but the lag due to the viscosity of the heavier oils makes this impractical.

The dropping-tip, *c*, consists of capillary tubing 1 mm. in diameter sealed on the pipette as shown. The internal diameter of the tip should be 1.00 mm. ± 0.01 mm. The tip is ground and polished smooth and level so that when in position the plane of the tip is absolutely horizontal. This form of tip has been found more substantial and more easily duplicated than other forms.[2] It was found that by proper manipulation as prescribed below, the drop would form on the inner edge of the tip. The grinding and polishing of this tip to insure a true circle is comparatively simple.

The over-all height of the pipette from the zero mark to the tip should be approximately 40 cm. The exact size of the bulbed portions of the pipette is not essential.

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[1] *Donnan-Zeit. fur Physikal. Chem.*, 31–42 (1899).

[2] Morgan, *Journal*, Am. Chemical Soc., Vol. 37, p. 1461 (1915), and Harkins, *Journal*, Am. Chemical Soc., Vol. 38, p. 236 (1916).

The flow regulator, *g*, is partially filled with a fairly viscous oil (viscosity 200 to 300 seconds at 100° F.). During the test this oil flows into the chamber *h* which is so constructed that none of this oil enters the pipette proper and at the end of a test is drawn back into the reservoir *g*.

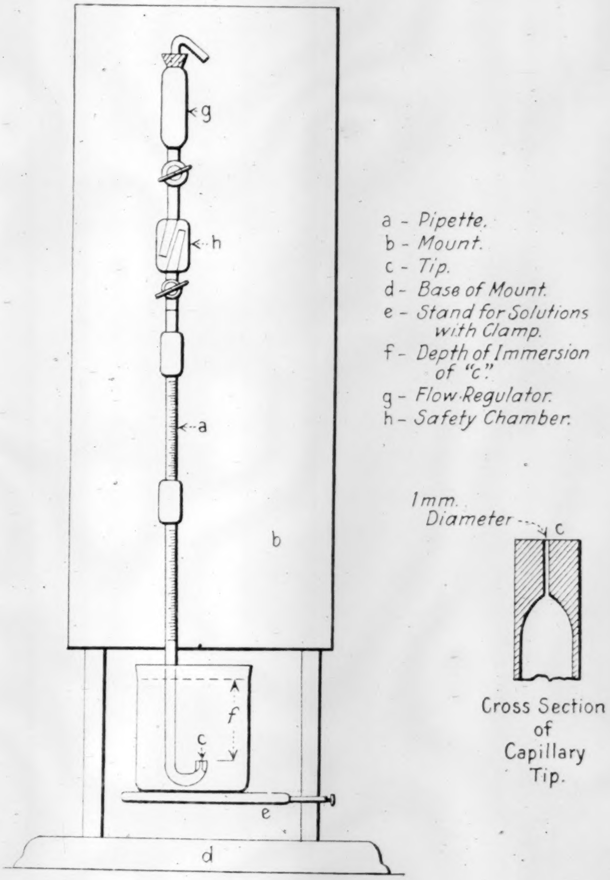
g
h
a
b
c
f
e
d
a - Pipette.
b - Mount.
c - Tip.
d - Base of Mount.
e - Stand for Solutions with Clamp.
f - Depth of Immersion of "c."
g - Flow Regulator.
h - Safety Chamber.
1 mm. Diameter
c
Cross Section of Capillary Tip.

FIG. 1.—Apparatus Used in Measuring Emulsifying Tendency of Oils by Surface Tension

METHOD OF OPERATION

Filling the Pipette.—A small beaker (50 cc.) of the oil to be tested is placed so that the tip is immersed and the pipette is then filled to a point slightly above the zero mark by suction applied to the flow regulator *g*. The stop-cock between *g* and *h* is closed and the stop-cock between *h* and *a* left open. The tip *c* is then wiped off carefully with cotton or cheese cloth.

A beaker of distilled water (or 0.01 *N* sodium hydroxide solution) is then put in place so that the tip is immersed about 5 cm. below the level of the liquid. This beaker can be of any convenient size. The type best suited for the purpose is the tall form and of about 150 cc. capacity.

Determination.—The immersion of the tip in the water will force the oil back into the pipette a short distance. This is extremely desirable for thus the inner edge of the glass tip becomes wetted by the water and subsequently the contact will in reality be between the oil and the water instead of between the oil and the glass. This expedites the regular formation of smooth perfectly-shaped drops. As the stop-cock between *h* and *a* is open, the level of the oil in the pipette can be brought to the zero mark by carefully regulating the cock between *g* and *h*. Any oil on the tip is now dislodged by means of a clean glass rod.

The stop-cock between *g* and *h* is now regulated to cause the slow formation of drops on the tip *c*. It is extremely important that the drops be formed slowly, especially the latter part of the drop just before rupture. Therefore it is prescribed that the drops be formed at the rate of one every 30 seconds (2 per minute). After a short amount of experience the operator will be able to regulate the flow quite easily and then perfectly shaped drops and absolutely concordant results will be obtained.

With this rate of formation of drops, the operator merely observes how many drops are formed while the oil falls to the 1 or 2-cc. mark, more or less. The graduations near the 1 and 2-cc. marks enable the operator to stop the run at the end of a completed drop. After allowing a short time (30 seconds) for drainage, the exact volume required to make the noted number of drops is read and the drop size then calculated and expressed in cubic centimeters per 100 drops.

The two bulbs in the pipette enable the operator to take care of oils of widely different drop size. Thus in an oil of small drop size sufficient accuracy will be obtained by noting how many drops are formed in 1 cc., while in oils with a large drop size it will be necessary for the sake of accuracy to note the number of drops in 2 cc. Therefore, if less than 10 drops are formed by 1 cc. of the oil, the observation should be continued to the 2-cc. mark.

The operation is repeated with 0.01 *N* sodium hydroxide solution (or distilled water) in exactly the same manner.

TABLE I.—COMPARISON OF RESULTS BY VARIOUS METHODS IN MEASURING EMULSIFICATION OF LUBRICATING OILS

Oil	Emulsification by Surface Tension			R. E. Value (minutes)	Navy Tests			Conradson Steam Test								Gravity, deg. A. P. I.	Viscosity, 100° F., sec.
	Size of Drop,[1] H_2O	Size of Drop,[1] NaOH	Ratio Drop Size, *K*		NaOH	H_2O	NaCl										
No. 1	2.05	2.00	0.976	0.5	40–40–0	40–40–0	40–40–0	44	Clear	0	......	102	Cloudy	2	100%	30.7	175
	2.02	1.98	0.980	1.0	40–40–0	40–40–0	40–40–0	45	Clear	0	......	101	Cloudy	1	100%		176
No. 2	1.57	1.26	0.804	1.0	40–40–0	40–40–0	40–40–0	45	Clear	0	......	103	Cloudy	3	100%	31.6	143
	1.55	1.28	0.827	2.5	40–40–0	40–40–0	40–40–0	44	Clear	0	......	102	Cloudy	2	100%		141
No. 3	2.19	2.01	0.920	3.5	40–40–0	40–40–0	40–40–0	44	Clear	0	......	101	Cloudy	1	100%	26.1	229
	2.15	1.95	0.908	2.5	40–40–0	40–40–0	40–40–0	45	Clear	0	......	102	Cloudy	2	100%		223
No. 4	2.12	1.86	0.878	20.0	30–35–15	40–40–0	40–40–0	40	Milky	4	Coarse	101	Cloudy	1	100%	25.8	455
	2.15	1.89	0.880	20.0	0–65–15	40–40–0	40–40–0	41	Milky	5	Coarse	100	Cloudy	0	100%		457
No. 5	1.80	1.52	0.845	1.0	40–40–0	40–40–0	40–40–0	44	Clear	0	......	102	Cloudy	2	100%	30.3	141
	1.82	1.52	0.837	1.0	40–40–0	40–40–0	40–40–0	45	Clear	0	......	101	Cloudy	1	100%		143
No. 6	2.36	1.73	0.735	2.0	38–34–8	40–40–0	40–40–0	45	Clear	0	......	101	Cloudy	1	100%	25.5	270
	2.32	1.70	0.734	2.5	37–35–8	40–40–0	40–40–0	44	Clear	0	......	102	Cloudy	2	100%		270
No. 7	2.24	1.02	0.455	11.0	5–30–45	40–40–0	40–40–0	45	Clear	0	......	103	Cloudy	3	100%	23.8	347
	2.27	1.02	0.450	15.0	0–32–48	40–40–0	40–40–0	40	Clear	4	Coarse	100	Cloudy	0	100%		348
No. 8	2.48	1.08	0.436	20.0	5–34–41	40–40–0	40–40–0	44	Clear	0	......	100	Cloudy	0	100%	23.3	578
	2.50	1.05	0.420	18.0	3–32–45	40–40–0	40–40–0	10	Milky	40	Coarse	90	Cloudy	.	...		588
No. 9	2.02	1.90	0.940	1.0	40–40–0	40–40–0	40–40–0	44	Clear	0	......	101	Cloudy	1	100%	29.3	143
	2.05	1.92	0.936	1.5	40–40–0	40–40–0	40–40–0	45	Clear	0	......	102	Cloudy	2	100%		143
No. 10	3.46	2.97	0.860	2.5	40–40–0	40–40–0	40–40–0	44	Clear	0	......	101	Cloudy	1	100%	20.9	280
	3.50	3.00	0.857	5.0	40–40–0	40–40–0	40–40–0	45	Clear	0	......	102	Cloudy	2	100%		283
No. 11	3.25	0.79	0.243	20.0	0–35–45	40–40–0	40–40–0	40	Milky	20	Coarse	74	Cloudy	0	74%	20.0	443
	3.22	0.80	0.248	20.0	0–30–50	40–40–0	40–40–0	42	Milky	10	Coarse	99	Cloudy	0	99%		443
No. 12	2.87	1.02	0.356	20.0	0–36–44	5–38–37	40–40–0	44	Milky	20	Coarse	95	Cloudy	0	95%	19.9	230
	2.90	1.00	0.345	20.0	0–30–50	7–37–36	40–40–0	42	Milky	4	Coarse	99	Cloudy	0	99%		228
No. 13	2.50	0.05	0.020	8.0	0–36–44	40–40–0	40–40–0	45	Clear	0	......	101	Cloudy	1	100%	21.5	145
	2.45	0.05	0.020	13.0	0–35–45	40–40–0	40–40–0	46	Clear	0	......	102	Cloudy	2	100%		144
No. 14	2.90	0.12	0.041	7.0	0–38–42	38–35–7	40–40–0	45	Milky	10	Coarse	95	Cloudy	0	95%	20.8	218
	2.95	0.12	0.034	4.0	0–37–43	35–35–10	40–40–0	47	Milky	15	Coarse	97	Cloudy	0	97%		220

This size of drop is given in empirial units adopted for comparative work.

Cleaning the Pipette.—The pipette can easily be cleaned and excess oil from a previous determination be removed by repeatedly filling the pipette with very light gasoline. This is accomplished by submerging the tip in light gasoline, filling by suction and repeating the operation four or five times. A current of air drawn through the pipette will then dry it very quickly.

INTERPRETATION OF RESULTS

The drop size expressed most conveniently in cubic centimeters per drop will then be known for both the water and the 0.01 N caustic interfaces. The value of the ratio K is then easily calculated.

If this value is greater than 0.75, that is, between 0.75 and unity, the oil will separate satisfactorily from emulsions with neutral, acid, or alkaline waters and the nearer this value approaches unity the better the oil. If the value of K is below 0.75, the oil will be unsatisfactory and will be inclined toward forming "permanent" emulsions in lubricating systems.

The nearer K approaches unity the greater is the value for resisting troublesome emulsions. The factor K is also an exact numerical expression of the relative value of the oil as regards this quality. It has been found that all highly refined oils approach the same value for K. A number of such examples are given in Table I.

DISCUSSION OF THE FACTORS

The factors which affect the method, its operation, and the results have been studied for the purpose of determining the optimum conditions to be recommended as standard.

Dimensions of the Apparatus.—The drop size is, of course, a function of the diameter of the tip. The effect of this variable for diameters near 1.0 mm. was determined very closely. Thus in the case of a given oil the variation in drop size with change in diameter was as follows:

DIAMETER OF TIP, MM.	DROP SIZE, CC. PER DROP
0.990	0.0693
1.000	0.0698
1.010	0.0703

It will, therefore, be evident that in allowing a variation of from 0.99 to 1.01 mm. in the diameter of the tip the effect in the drop size will be inappreciable. By the use of the factor K, greater variation in diameter than specified above may be allowable, for within fairly wide limits the influence of this variable on K is eliminated.

The tip of each pipette, however, should always be calibrated by means of measuring the drop size of c. p. benzol and thus checking the apparatus maker's measurement of the tip diameter. The findings of the laboratory indicate that with apparatus as specified above, a tip of the prescribed size should give a benzol drop size at the water interface of 0.0690 to 0.0695 cc. per drop.

The type of tip shown in Fig. 1 was found most satisfactory and more easily capable of exact duplication than those proposed elsewhere.[1]

The drop size is dependent upon the buoyancy of the drop of oil in the water and not upon the depth to which the tip is immersed.

The drop size does not vary with the height of the oil in the pipette if the drops are formed as prescribed, for under these conditions the pressure of the oil has an inappreciable effect upon the rupture of the drop.

The drop size is dependent upon the gravity of the oil under examination; that is, upon the difference in specific gravity between the water and the oil. The ratio *K* eliminates the influence of this variable and makes oils of different gravities comparable.

The surface tension is influenced by change of temperature. However, it has been found that the difference caused by slight changes in the laboratory room temperature have but a slight effect on the drop size. Furthermore, the drop size at the water and caustic interface are each affected in like degree with change of temperature and, therefore, in evaluating for *K* this effect is cancelled. It is, therefore, permissible to carry out the determination at room temperature, for no measurable error is involved.

Since viscosity and surface tension are both properties which are dependent principally upon molecular attraction, molecular association and dissociation, it is quite likely that they are related in some manner. Such inter-dependence, however, is not apparent from the study made in the laboratory. Though such relation should exist, it is evident that by the use of the factor *K*, oils of different viscosities are comparable.

It must be understood that an oil with a viscosity of 200 seconds and a value of $K = 0.800$ will separate more rapidly from an emulsion formed under some empirical set of conditions than will an oil of viscosity 500 seconds and having the same value of *K*. However, the extent to which the final separation takes place will be the same in each case. In comparing oils of the same approximate viscosity and gravity the rate of separation would be roughly proportional to their values of *K*.

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[1] Morgan, *loc. cit.* and Harkins, *loc. cit.*

It is of the greatest importance that the drop, especially the last portion thereof, be formed very slowly in order to obtain accurate determinations, for it is necessary to make the phenomenon as nearly static as possible.[1] Theoretically, the determination would be accurate only when there is no pressure, due to the effluent oil, at the moment of rupture. While this condition may theoretically be impossible, yet concordant results can be obtained if the rate prescribed above is maintained.

The strength of the sodium hydroxide solution used in measuring the surface tension at the oil-caustic interface has a pronounced effect upon the drop size. It is, therefore, necessary that the solution be $0.01\ N \pm 0.0002$.

In case of stronger solutions, the effect of any change in concentration upon the drop size is most marked. At or near the above concentration, the allowable variation has no measurable effect. Stronger solutions of caustic would be impractical, since the drop size would be exceedingly small except in the case of highly refined water-white oils.

COMPLIANCE WITH "IDEAL" FEATURES OF A GOOD TEST

The extent to which the above method complies with the prerequisite features of a good test as outlined in the Report of Sub-Committee XI on Emulsification, of Committee D-2,[2] is indicated below:

1. *Ease of Operation.*—After a slight amount of instruction and experience, the average tester could operate the apparatus and obtain concordant results. It is, of course, necessary that the operator count the number of drops formed, read the volume and calculate the drop size; however, this is not complicated and could be handled by the average tester.

2. *Simplicity and Availability of Apparatus.*—The apparatus could be constructed by the average apparatus maker, and it is certain that it could be furnished by him at a low cost.

3. *Negligible Personal Equation.*—After a slight amount of experience, any operator could produce results which would be absolutely independent of the individual.

4. *Reproducibility of Results.*—As the apparatus is easy of duplication and the personal element negligible, there is no reason why the results of such a test can not be checked by different operators in different laboratories with equipment standardized as specified above.

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[1] Lord Rayleigh, *Phil. Mag.* (5)–48–321 (1899).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 431 (1922).

Different instruments of this type operated by different comparatively-inexperienced testers in the laboratory have given concordant results.

5. *Sample of Small Size.*—The amount of oil actually consumed is approximately 4 cc., although a larger volume should be available for the convenient filling of the pipette. For this purpose, 20 cc. is sufficient, and the surplus is available for other tests. Furthermore, this extra amount is not absolutely necessary, since the pipette could be filled with a funnel if the amount of oil is limited.

6. *Time Required.*—The determination will require a maximum of 30 minutes, which includes the time for cleaning and filling the pipette.

7. *Results Indicative of the Value of the Oil and Its Behavior in Practice.*—Any mineral oil will form an emulsion with water if the two liquids are mixed with sufficient intimacy; that is, if the oil or the water is subdivided into globules that are sufficiently small and these globules are dispersed uniformly throughout the other liquid.

Only in a very general way can it be said that the ease with which an emulsion forms is an index of its tendency to form permanent emulsion. There are too many uncontrollable and indefinable variables influencing the formation to allow the prescribing of standard conditions for the formation of emulsions and to make this the basis of a method of testing its emulsifying tendency.

The extent to which an emulsion will separate into its components depends upon the surface tension at the interface between the oil and aqueous solution. The lower the value of the surface tension, the less the tendency toward separation. The greater the surface tension the more pronounced the tendency toward separation. This tendency toward separation is directly proportional to the value of the interfacial surface tension.

The speed with which an emulsion separates into its components is not only influenced by its interfacial surface tension but also by the intimacy of contact, that is, the size of the particles of the dispersed phase, the specific gravity of the oil, the viscosity, and the temperature. The exact influence upon the speed of separation of each of these factors when acting simultaneously has never been clearly demonstrated. It, therefore, seems questionable whether any method of testing which is based on the speed of separation can be a true measure of the value of the oil.

The conditions under which emulsions are formed in circulatory systems vary so much that it is useless to attempt to prescribe standard means of forming emulsions which could even resemble the average conditions. No matter how good an oil is, it will eventually be subjected to such conditions that it will form an emulsion.

Any method of testing which involves the formation of an emulsion and the observation of the subsequent behavior of this emulsion will therefore be open to grave objections because of the extreme difficulty of reproducing the exact conditions of emulsion formation and the difficulty of properly interpreting the observation during the separation period.

Whatever the conditions of formation of an emulsion of an oil and water, the tendency to separate will be dependent upon the interfacial surface tension. A measurement of the relative or absolute surface tension at the water interface, therefore, is the basis of a true criterion of the value of the oil.

Conditions arise in actual practice under which the oil is exposed to alkaline waters. In order that any method of testing be of general applicability it seems necessary to test the tendency of the oil toward forming permanent emulsions with such alkaline waters. For this purpose an 0.01 *N* sodium hydroxide solution has been empirically chosen. This concentration has seemed most advisable because if the water in the lubricating system does become alkaline it would seldom have an alkalinity greater than the equivalent of 0.01 *N* sodium hydroxide (40 parts per 100,000). A concentration as great as 1 *N* would be undesirable:

1. Because this is considerably greater than any waters found in practice.

2. Because under certain conditions of oil-contamination this excess of sodium hydroxide might have a "salting-out" effect.

3. Because the drops would be exceedingly small except in the case of highly-refined white oils.

The ratio of the drop size at the caustic interface to the drop size at the water interface has been termed *K*. The value of *K* is undoubtedly a true measure of the tendency of the oil to emulsify with alkaline waters.

The laboratory of the author has tested 15 lubricating oils which are offered on the market by the various oil companies as turbine oils and which are leaders in this field of lubrication; also 65 to 70 other lubricating oils which are offered by the different companies in the other fields of lubrication. It has been found in every case where the value of the factor *K* was above 0.75, the oil separated satisfactorily from alkaline emulsions and passed the Navy Caustic Test as well as all the other emulsion tests. Furthermore, those oils which were known to be most satisfactory in service had a value of *K* between

0.8 and 0.97. Table I gives these values of K for the turbine oils mentioned above together with the Navy test, R. E. test and Conradson steaming test.

In setting the empirical standard of $K = 0.75$, the test insures that the oil will not form permanent emulsions with alkaline waters and will be even more satisfactory in the case of neutral water.

The test is particularly sensitive in testing oils of "Class 3", that is, oils of doubtful quality. The slightest change in the quality of an oil of the doubtful class is indicated in the value of K. Thus the test not only distinguishes readily and accurately between a good and a bad oil, but also designates numerically the exact quality and value of the oil.

REPORT OF SUB-COMMITTEE XII ON FLASH

Sub-Committee XII on Flash has studied the desirability of introducing three modifications in the Tentative Method of Test for Flash and Fire Points by Means of Open Cup (D 92 – 21 T).[1] The modifications involve:

1. A change in the plate supporting the cup. The present solid plate renders it difficult to maintain the specified rate of heating for high-flash oils, and it was found that cutting out part of the portion of the plate beneath the bottom of the cup increased the convenience and did not appreciably change the results.

2. The permitting of a more rapid rate of heating for the temperature range extending up to 100° F. below the flash point. This does not change the results and saves some time in making the test.

3. Clarifying the directions so there will be no possibility of misunderstanding the directions for applying the flame when determining the fire point.

It is accordingly recommended that the method of test be continued as tentative with the following revisions:

Section 2.—Change the second paragraph from its present form: namely,

> "The cup shall be heated by contact with a metal plate $\frac{1}{4}$ in. (0.635 cm.) thick and 6 in. (15.24 cm.) wide. (The plate may be of any suitable metal and may be either circular or square.) In the center of the plate there shall be a plane depression of $\frac{1}{32}$ in. (0.079 cm.) deep and of diameter just sufficient to fit the cup. The plate shall be covered with a sheet of hard asbestos board $\frac{1}{4}$ in. (0.635 cm.) thick and of the same shape as the metal plate. There shall be cut in the center of the asbestos board a circular hole just fitting the cup. The metal plate may be heated in any convenient manner. The use of a gas burner, electric heater, or alcohol lamp is permitted. If a flame heater is used it may be protected from drafts or excessive radiation by any suitable type of shield that does not project above the level of the upper surface of the asbestos board.

to read as follows:

> "The cup shall be heated by contact with a metal plate $\frac{1}{4}$ in. (0.635 cm.) in thickness and 6 in. (15.24 cm.) in width. The plate shall be of brass, cast iron, wrought iron or steel. In the center of the plate there shall be a plane depression $\frac{1}{32}$ in. (0.079 cm.) in depth, and of just sufficient diameter to fit the cup. There shall be a circular opening $2\frac{3}{16}$ in. (5.50 cm.) in diameter, cut through the plate, centering with the center of the above-mentioned depression. The plate shall be covered with a sheet of hard asbestos board $\frac{1}{4}$ in. in thickness and of the same shape as the metal plate. There shall be cut in the center of the asbestos board a circular hole just filling the cup. Heat may be supplied from

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 651 (1921).

any convenient source. The use of a gas burner, electric heater, or alcohol lamp is permitted, but under no circumstances are products of combustion or free flame allowed to come up around the cup. The source of heat shall be centered under the opening in the plate and shall be of a type that will not produce local superheating. If a flame heater is used, it may be protected from drafts or excessive radiation by any suitable type of shield, that does not project above the level of the upper surface of the asbestos board."

Section 4 (e).—Change from its present form: namely,

"The rate of heating of the oil shall be such that the temperature read on the thermometer increases not less than 9 nor more than 11° F. per minute."

to read as follows:

"The oil shall be heated at a rate not exceeding 30° F. per minute temperature rise, till a point is reached approximately 100° F. below the probable flash point of the oil. Thereafter the rate of heating shall be decreased and for at least the last 50° F. before the flash point is reached, the rate shall be not less than 9 nor more than 11° F. per minute."

Section 6.—Change from its present form: namely,

"After determining the flash point the heating shall be continued at the specified rate, and application of the test flame shall be made at the specified intervals until the oil ignites and continues to burn for a period of at least five seconds. The temperature read when this occurs shall be taken as the fire point."

to read as follows:

"6. After determining the flash point, the heating shall be continued at the specified rate of 9 to 11° F. per minute, and application of the test flame shall be made at the specified intervals until the oil ignites and continues to burn for a period of at least 5 seconds. The method of application of the flame shall be the same as for flash point. The temperature read at the time of the flame application which causes burning for a period of 5 seconds or more shall be recorded as the fire point."

Respectfully submitted on behalf of the sub-committee,

ERNEST W. DEAN,
Chairman.

REPORT OF SUB-COMMITTEE XIII ON ORGANIC ACIDITY AND SAPONIFICATION

As part of the sub-committee's work on collaborative tests, seven samples of mineral oil were sent to the members of the sub-committee for the determination of organic acidity by three different methods. The first method was the free acid test for fatty oils described in Section 2 of the Standard Methods of Testing Lubricants (D 47 – 21).[1] The second method was the free acid test for mineral oils, described in the same section. Method No. 3 was new and consisted in weighing 40 g. of the oil into a flask, adding 50 cc. of petroleum naphtha having a specific gravity at 60° F. of 0.695 to 0.705, an initial boiling point, A.S.T.M., of 113 to 131° F., and an end point, A.S.T.M., not higher than 248° F. After adding 100 cc. of 95-per-cent ethyl alcohol, it was warmed on a steam bath, phenolphthalein added, and then titrated with 0.1*N* NaOH or 0.1*N* KOH solution. Table I shows the results of tests with these methods.

Table I.—Comparative Tests of Organic Acidity, Expressed in Milligrams of KOH per Gram of Oil

	Sample						
	1	2	3	4	5	6	7
				Method No. 1			
Union Oil Co. of California	0.766	0.065	0.055	0.356	0.118	1.813	1.283
Associated Oil Co.	0.79	0.025	0.029	0.21	0.06	1.75	1.56
Standard Oil Co., Indiana, phenol	1.00	0.04	0.09	0.47	0.13	2.27	1.52
Standard Oil Co., Indiana, alkaline blue	.....	.....	0.08	0.38	0.09	.....	.....
Texas Co.	0.771	0.053	0.038	0.653	0.096	2.282	1.156
Mellon Institute	0.85	0.048	0.085	0.48	0.16	2.34	.....
Bureau of Standards	1.09	0.14	0.03	0.62	0.28	2.60	1.40
				Method No. 2			
Union Oil Co. of California	0.769	0.045	0.025	0.236	0.072	1.111	1.103
Associated Oil Co., alkaline blue	0.50	0.01	0.01	0.14	0.07	1.45	1.30
Associated Oil Co., phenol	0.37	0.017	0.011	0.33	0.05	0.99	1.54
Standard Oil Co., Indiana	0.79	0.06	0.05	0.25	0.08	1.62	1.20
Texas Co.	0.658	0.043	0.040	0.177	–0.086	1.515	1.017
Bureau of Standards	0.98	0.09	0.03	0.45	0.12	1.61	1.54
				Method No. 3			
Union Oil Co. of California	0.740	0.033	0.037	0.309	0.076	1.713	1.272
Associated Oil Co.	0.985	0.05	0.028	0.27	0.07	2.17	1.66
Standard Oil Co., Indiana	0.97	0.04	0.05	0.47	0.09	2.38	1.49
Texas Co.	0.802	0.017	0.018	0.552	0.058	2.080	1.927
Bureau of Standards	1.05	0.10	0.08	0.65	0.31	2.55	1.36

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[1] 1921 Book of A.S.T.M. Standards.

It was the general opinion that Method No. 1 was the best of the three and that it could be improved by using 20 instead of 10 g. of oil, but it was not felt that a definite proposal for modifying the present standard should be made until further work had been done.

Respectfully submitted on behalf of the sub-committee,

Winslow H. Herschel,
Chairman.

REPORT OF SUB-COMMITTEE XV ON SAMPLING AND GAGING

The sub-committee has undertaken to present, first, suitable methods for sampling petroleum products from various kinds of containers and to then consider the subject of gaging.

It is contemplated that methods of procedure will be developed for the taking of representative samples of oil or of the derivatives of oil from such of the several classes of containers as are common to oil refineries, or to the consumers of oil refinery products or are involved in conveying oil to or from an oil refinery.

TENTATIVE PROGRAM ON SAMPLING

The several classes of oils and derivatives of oil which should be considered in this connection are:

1. Crude petroleum.
2. Crude volatile distillates.
3. Crude non-volatile distillates.
4. Refined volatile distillates.
5. Refined non-volatile distillates.
6. Liquid residues.
7. Solid or semi-solid residues.
8. Miscellaneous.

The several classes of containers from which a sample is to be taken are:

1. Tank boats or barges.
2. Shore tanks.
3. Pipe lines.
4. Tank cars, liquid.
5. Tank cars, solid.
6. Barrels, liquid.
7. Barrels, solid.
8. Cans, liquid.
9. Cans, solid.
10. Cakes, solid.

In order to establish a line of distinction between volatile and non-volatile products and between liquid and solid or semi-solid products the following classification is proposed:

1. Volatile.—Gasoline and naphthas, (*a*) having a flash point (Tag closed) below 100° F. or (*b*) having a gravity above 45° Baumé.
2. Non-volatile.—Oils, etc., having a flash point of 100° F. or more, kerosene, etc.
3. Liquids.—Oils, etc., which at a temperature of 70° F. will flow readily from the barrel bung hole of not less than 1 in. in diameter.
4. Semi-solid and solid.—Oil, etc., which must be heated to temperatures above 70° F. to facilitate handling through pump and pipe lines.

The purpose of this classification is to show that:

1. Samples of a certain class may be taken at ordinary atmospheric temperature.
2. Samples of other classes can only be taken after the material is heated.
3. Samples of a certain class must be placed in a tight container and closed promptly.
4. Samples of other classes may be placed in slack containers and closed at leisure.
5. Samples may be taken with a thief.
6. Samples must be taken by other means than with a thief.

Samples must be taken under at least two different conditions, such as:

1. From containers such as a shore tank or tank boat or in barrels or cans.
2. While passing from one container to another as in pumping from one tank car or boat to a shore tank or *vice versa.*

Samples shall be taken to represent:

1. The average condition of contents of a container such as a tank.
2. The average condition of the contents of a number of containers such as a shipment in barrels.
3. The condition of a certain stratum of material in a container.

Samples may be taken by means of:

1. A drip from the discharge pipe.
2. A thief or small flask.
3. An auger (for solids).

Proposed methods for sampling oils and wax which are now under discussion in the sub-committee are appended hereto.

Respectfully submitted on behalf of the sub-committee,

C. N. FORREST,
Chairman.

APPENDIX

PROPOSED METHOD FOR SAMPLING PETROLEUM PRODUCTS

LIQUID OILS FROM TANK BOATS OR BARGES, SHORE TANKS OR CARS

1. Liquid oils are those which may be handled through pumps and pipe lines at or below a temperature of approximately 70° F.

2. Individual samples shall be taken by means of a "thief" having a capacity of at least one pint, and so arranged with valves under the control of the operator that a selected portion of the contents of a tank may be sampled without contamination by other portions of the same tank.

> NOTE.—The advisability of developing a suitable form of "thief" is suggested as proper work for Sub-Committee XV.

3. The following precautions shall be observed in taking samples of oils:

(*a*) The containers for samples shall be clean and dry.

(*b*) The operator shall have clean hands and wear no gloves. The thief and all of its attachments shall be so clean as not to impart color to water white gasoline.

4. *Average Sample.*—An average sample is one which contains the same amount of oil from all depths of the tank.

It shall be taken by lowering a "thief" with valves closed, to the bottom of the tank. The upper valve is then opened and the "thief" immediately drawn upwards at a suitable uniform rate of speed so that when it leaves the oil it will lack approximately one inch of being full. If the "thief" is full or lacks more than one inch of being full when it leaves the oil, that sample shall be discarded and another trial or other trials made at a different rate of speed until the requirements are met.

5. (*a*) A top sample is one taken not more than one inch below the surface of the oil.

(*b*) A middle sample is one taken at a point midway between the top and bottom sample.

(*c*) A bottom sample is one taken not more than one inch below the bottom outlet or the bottom manhole of the tank.

(*d*) A composite sample shall consist of an equal volume of the top, middle and bottom samples which has been placed in a single container and thoroughly mixed.

SEMI-LIQUID OR SEMI-SOLID OILS

6. Semi-liquid oils are those which must be heated to temperatures above 70° F. to be handled through pumps and pipe lines.

7. After they are suitably heated, semi-liquid oils shall be sampled by means of a "thief" exactly as directed in Sections 2 to 5, inclusive.

PARAFFIN WAX

(ADOPTED FROM THE SUGGESTIONS OF DR. FRANCIS)

8. *Liquid or Semi-Liquid Wax*—By means of a thief, approximately one pint of wax shall be taken, respectively, from the top, middle and bottom of the tank or other vessel as directed in Section 5 and placed in a 1-pint friction-top tin can.

These three samples shall be liquified by placing the container in hot water and each thoroughly mixed. One-third of the contents of each container shall then be placed in one dry, clean bottle or can and will thus constitute an average sample of the contents of the tank.

9. *Solid Wax in Cases, Barrels or Bags.*—If foreign substances, such as dirt, sticks, string, etc., appear upon or near the surface of the wax, they shall be removed or otherwise discarded from the sample. Such foreign matter, if contained in the body of the wax shall not be discarded.

10. Solid wax shall be sampled with a $\frac{3}{4}$-in. ships auger.

11. Cases and barrels shall have the heads removed. Bags shall have the mouths opened.

12. Three test holes shall be bored in each package of wax extending from the top to the bottom of its contents.

(*a*) At the center of the package.

(*b*) At a point three-quarters of the distance from the center to the right side of the package.

(*c*) At a point three-quarters of the distance from the center to the left side of the package.

The borings from each hole shall be saved in separate packages.

They shall then be combined in one container as an average sample of the package sampled or else they shall each be chilled to permit of pulverizing and quartering down to approximately $\frac{1}{4}$ lb. After thus preparing the three separate samples, $\frac{1}{4}$ lb. or an equal weight of each of them shall be placed in a single one-pint can as an average sample of the package sampled.

LIQUID OILS FROM BARRELS, DRUMS AND CANS

13. Barrels and drums of oil shall be sampled from a bung hole in the side of such containers. Cans shall be sampled through the opening used in filling them.

14. The contents of a barrel, drum or can is regarded as already thoroughly mixed and therefore homogeneous, consequently such packages are to be sampled as they lie, either by means of a pipette type of thief or by inclining the container in an appropriate manner to spill its contents.

A pipe nipple about 6 in. long or a truncated cone of sheet metal open at both ends, inserted in the bung hole of a barrel or drum will serve as a spout and facilitate sampling without waste of material, from such packages.

SEMI-LIQUID OR SEMI-SOLID OILS

15. The container of semi-liquid or semi-solid materials shall be placed in a warm place until the contents become sufficiently liquid to be sampled according to the method prescribed in Sections 13 and 14.

OILS FROM PIPE LINES

16. Pipe line samples shall be taken by drip method over an established period of time and shall be regarded as an average sample of the oil passing through the pipe for such a period.

17. The drip for pipe line samples shall be located in the under side of a horizontal length of the line. The drip opening shall be of uniform bore of a stated size, according to the volume of sample desired, and the slotted lead to the drip opening shall extend into the line for the full diameter of the same.

18. The drip sample from pipe lines shall be received directly into a closed but vented vessel, which has been cleaned and dried just previous to its use. Such vessels shall not exceed 5-gal. capacity and the contents of these shall be mixed or homogenized by shaking the vessel, if it is desired to take a smaller average sample from the same.

NOTE.—All samples of oil shall be placed in clean, dry bottles or cans, usually of one-pint capacity, which can be closed tight immediately to prevent evaporation.

REPORT OF SUB-COMMITTEE XVI ON CLOUD AND POUR TEST

The sub-committee has been engaged in making thorough comparative tests with the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (D 97 – 22 T). A sample of mid-continent fuel oil was first sent out to the members of the sub-committee for pour point determinations. The results as tabulated below were obtained:

	Date of Test	Pour Point, Deg. Fahr.	Bath Temperature
Member No. 1	November 6, 1922	60	33 to 35° F.
	November 7, 1922	60	33 to 35° F
	November 11, 1922	60	33 to 35° F.
Member No. 2	November 13, 1922	55	3° F
	November 13, 1922	55	3° F.
	November 13, 1922	55	3° F
	November 13, 1922	55	32° F.
	November 13, 1922	55	32° F.
	November 13, 1922	55	32° F.
	November 14, 1922	55	32° F.
	November 14, 1922	55	32° F
	November 14, 1922	55	32° F.
	November 15, 1922	55	32° F.
	November 15, 1922	55	32° F.
	November 15, 1922	55	32° F.
Member No. 3	January 5, 1923	65	40° F.
	January 16, 1923	65	0° F.
	January 17, 1923	65	40° F.
Member No. 4	3 tests each by 3 operators	55	No bath temperature given
Member No. 5	October 31, 1922	55	25° F.
	October 31, 1922	55	25° F.
	November 1, 1922	55	20° F.
	November 3, 1922	55	20° F.
Member No. 6	November 15, 1922	55	0° F.
	November 16, 1922	55	10° F.
	November 17, 1922	55	15° F.
	November 20, 1922	55	34° F.
Member No. 7	November 13, 1922	55	30° F.
	November 13, 1922	55	30° F.
	November 15, 1922	55	32° F.
	November 15, 1922	55	32° F.
	November 22, 1922	55	32° F.
	November 22, 1922	55	32° F.

	Date of Test	Pour Point, Deg. Fahr.	Bath Temperature
Member No. 8	November 5, 1922	55	30° F.
	November 5, 1922	55	30° F.
	November 8, 1922	55	20° F.
	November 8, 1922	55	20° F.

The above check results were in many cases obtained by different operators and as a whole indicate the reliability of the method for the type of oil tested.

Early in 1923, samples of a mid-continent gas oil and automobile crank case oil made from California crude oil were sent out to the members for comparative tests with the following results:

MID-CONTINENT GAS OIL

	Date of Test	Number of Tests Made	Pour Point, Deg. Fahr.	Bath Temperature
Member No. 1	February 16, 1923	3	40	0° F.
	February 17, 1923	3	40	−20° F.
Member No. 2	January 26, 1923	1	35	8° F.
	January 26, 1923	1	35	10° F.
	January 27, 1923	1	35	15° F.
	January 27, 1923	1	35	−15° F.
Member No. 3	March 25, 1923	1	35	5° F.
	March 25, 1923	1	35	15° F.
	March 25, 1923	1	35	20° F.
Member No. 4	January 24, 1923	6	35	−10° F.
	January 24, 1923	6	35	15° F.
Member No. 5	January 19, 1923	2	35	0° F.
	January 20, 1923	1	35	0° F.
	February 6, 1923	2	35	5° F.
	February 6, 1923	2	40	−20° F.
	February 7, 1923	1	35	5° F.
	February 7, 1923	1	40	−20° F.
Member No. 6	February 24, 1923	1	40	0° F.
	February 26, 1923	1	40	0° F.
	February 27, 1923	1	40	− 5° F.
	February 28, 1923	1	40	−12° F.
	March 2, 1923	1	40	−22° F.
	March 5, 1923	1	40	−28° F.
Member No. 7	No returns			
Member No. 8	March 10, 1923	2	40	10° F.
	March 13, 1923	2	40	5° F.

The results on the gas oil also indicate the method should be reliable for such an oil.

LUBRICATING OIL FROM CALIFORNIA CRUDE

	Date of Test	Pour Point, Deg. Fahr.	Bath Temperature
Member No. 1	February 16, 1923	5	0° F.
	February 17, 1923	5	−15° F.
	February 17, 1923	5	−20° F.
Member No. 2	January 31, 1923	0	−65° F.(approx.
	February 1, 1923	0	−25° F.
	February 1, 1923	0	−30° F.
	February 2, 1923	0	−25° F.
Member No. 3	March 29, 1923	−15	Not stated
Member No. 4	January 24, 1923	−10	−10° F.
Member No. 5	February 6, 1923	−10	−35° F.
	February 6, 1923	−10	−65° F.
	February 7, 1923	−10	−35° F.
	February 7, 1923	−10	−65° F.
Member No. 6	February 27, 1923	0	− 5° F.
	February 28, 1923	0	−12° F.
	March 1, 1923	0	−10° F.
	March 2, 1923	0	−10° F.
	March 2, 1923	0	−22° F.
	March 5, 1923	0	−28° F.
Member No. 7	No returns		
Member No. 8	March 10, 1923	10	−10° F.
	March 13, 1925	10	− 5° F.

The results are decidedly discordant and indicate that more work must be done on the determination of the pour point of lubricating oils having a pour point around 0° F.

It is recommended that the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (Serial Designation: D 97 – 22 T)[1] be revised as follows:

Section 11.—Change the next to the last paragraph to read as follows by the addition of the italicized words and the omission of the words in brackets:

"At each test thermometer reading which is a multiple of 5° F., the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether [the oil around the thermometer remains liquid] *there is a movement of the oil in the test jar.* [As long as the oil around the thermometer flows when the jar is tilted slightly, the test jar shall be replaced in the jacket]. The complete operation of removal and replacement shall require not more than three seconds. As soon as the oil [around the thermometer] *in the test jar* does not flow when the jar is tilted [slightly], the test jar shall be held in a horizontal position for exactly five seconds, *as noted by a stop watch, or other accurate timing device,* and observed carefully. If the oil [around the thermometer] shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure [shall be] repeated at the next temperature reading 5° F. lower. [In determining the pour point of oils it shall be noted that the first movement of the oil in certain cases is not around the thermometer but from the sides of the test jar. In such cases, this movement shall be considered in making the test. As soon as a temperature is reached at which the oil around the thermometer shows no movement when the test jar is held in a horizontal position for exactly five seconds, the test shall be stopped.]"

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 22, Part I, p. 781 (1922)

Change the last paragraph from its present form: namely,

> "The lowest reading of the test thermometer, corrected for error if necessary, at which the oil around the thermometer shows any movement when the test jar is held in a horizontal position for exactly five seconds shall be recorded as the pour point. It shall be noted that the pour point is the temperature 5° F above the solid point or temperature at which the test is discontinued."

to read as follows:

> "The test shall be continued in this manner until a point is reached at which the oil in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. The reading of the test thermometer at this temperature, corrected for error if necessary, shall be recorded The pour point shall be taken as the temperature 5° F. above this solid point."

The changes in these paragraphs are recommended because the sub-committee believes that any movement of the oil should be noted and not, specifically, movement around the thermometer. It is further recommended, in view of the results obtained on low pour point lubricating oil, to continue the method as tentative.

Respectfully submitted on behalf of the sub-committee,

RALPH R. MATTHEWS,
Chairman.

REPORT OF SUB-COMMITTEE XIX ON ILLUMINATING OILS

1. *Household Illuminating Oils.*—The proposed method for burning tests on household illuminating oils, appended hereto, was sent out to members of the sub-committee on December 23, 1922. Work in the chairman's laboratory on oils from California, Mexican, Pennsylvanian, and mid-continent crudes showed that with initial flame dimensions of $1\frac{3}{4}$ by $1\frac{3}{4}$ in., the initial rate of oil consumption was very close to 43 cc. per hour, and that rate was incorporated in the method. Some results obtained by this method are given in Table I.

Replies to this circularization were received from only three members of the sub-committee. Two of these were favorable and one made objections on a large number of points.

In view of the inadequate response to the chairman's circularization, it is recommended that the proposed method be printed as information.

Table I.—Oil Consumption Tests on Household Illuminating Oils

Source	Baumé Gravity	Specific Gravity	Oil Consumed, g.	Oil Consumed, cc.
California	40.1	0.8246	34.5	42
Mid-continent	42.3	0.8142	36.0	44
	....	......	35.0	43
Mid-continent	43.4	0.8091	35.0	43
Mid-continent	44.5	0.8040	35.0	44
Mexico	47.5	0.7905	35.0	44
Pennsylvania	47.5	0.7905	35.5	45

2. *Long Time Burning Oil.*—The work on this type of oil has been done entirely in the chairman's laboratory, and attention has been paid principally to the influence of the type of burner on the rate of oil consumption with the same flame setting. A reasonably satisfactory method of arriving at the initial rate of oil consumption was devised, and tests were made on five different types of long-time burners. The method consisted in putting 750 cc. of oil in the fount, setting the flame to $\frac{3}{4}$ in. measured from the top of the wick, using a sight gage accurate to $\frac{1}{32}$ in., with the fount in the lamp and slide open. The slide was then closed and the oil allowed to burn for one hour, readjusting the flame to $\frac{3}{4}$ in. if necessary. The fount and burner were removed from the lamp and weighed, while burning, on a torsion balance sensitive to 0.2 g. They were then replaced in the lamp and allowed to burn three hours longer. They were again removed and

weighed. From the weight of oil consumed and its specific gravity, the rate of oil consumption was calculated in cubic centimeters per hour. The results obtained, using a railway semaphore signal lamp, are given in Table II, and show that fixing a flame height without specifying the type of burner will lead to unlimited confusion, since there is a variation from 3.25 cc. per hour to 5.34 cc. per hour in the rate of oil consumption with the same oil in different types of burners.

TABLE II.—INFLUENCE OF STYLE OF BURNER ON INITIAL RATE OF OIL CONSUMPTION USING RAILWAY SIGNAL LAMP

Type of Burner	Weight at Start, g.	Weight at Finish, g.	Oil Consumed			
			In 3 Hours		In 1 Hour	Average, cc.
			g.	cc.	cc.	
Adams and Westlake, Type "A"	1107.8	1097.6	10.2	12.67	4.22	4.27
	1084.7	1074.3	10.4	12.93	4.31	
	1104.0	1093.7	10.3	12.81	4.27	
Adams and Westlake, Type "B"	1050.2	1040.3	9.9	12.30	4.10	4.23
	1031.6	1021.8	9.8	12.31	4.10	
	1055.2	1044.1	11.1	13.79	4.60	
Dressel Burner, Type "C"	1065.0	1053.3	11.7	14.54	4.85	4.76
	1086.0	1074.2	12.0	14.91	4.97	
	1057.2	1046.4	10.8	13.42	4.47	
Dressel Burner, Type "D"	1052.9	1045.6	7.3	9.07	3.02	3.23
	1045.0	1037.3	7.7	9.57	3.19	
	1037.7	1029.3	8.4	10.44	3.48	
Dressel Chimney Burner, Type "E"[a]	976.5	962.6	13.9	17.27	5.76	5.34
	991.7	980.0	11.7	14.51	4.84	
	966.3	953.2	13.1	16.27	5.42	

[a] It was impossible to get an accurate measurement of the flame with this type of burner.

There has been some objection to the development of a method which will limit the test to a definite type of equipment. If Committee D-2 sustains this view, then the development of a standard method for burning test on long time burning oils will have to be abandoned. This question is being submitted for decision of the committee.

Respectfully submitted on behalf of the sub-committee,

J. B. RATHER,
Chairman.

APPENDIX

Proposed Burning Test for Kerosene Oils

1. *Scope.*—The burning test for kerosene oil is intended for the determination of the burning quality of ordinary kerosenes used for illuminating purposes under specifications supplied by the buyer or where no specifications are supplied.

APPARATUS

2. (*a*) *Lamp.*—Standard brass Saybolt test lamp.

(*b*) Miller No. 2 sun-hinge burner.

(*c*) Macbeth-Evans No. 514 pearl top chimney.

(*d*) American Wick Co.'s "B" or No. 2 Wick.

(*e*) Sight gage for measuring the flame height and the width, accurate to $\frac{1}{16}$ in.

(*f*) 1000-cc. graduated cylinder.

(*g*) A pair of fine sharp scissors.

(*h*) A platform balance sensitive to 1 g.

3. *Burner.*—The burner shall be used as received from the manufacturer, but a burner may be rejected because of gross imperfections of manufacture. It shall be clean and in good condition at the start of the test, but emery paper shall not be used in cleaning nor imperfections removed by means of a file or otherwise.

4. *Wick.*—The wick shall be used as received from the manufacturer and shall not be extracted with ether or other solvent previous to use. A wick shall be rejected if it fits the wick-guide too loosely or too tightly, and a new wick shall be used for each burning test.

5. *Room.*—A special room for conducting the burning test is desirable, but the lamp may be burned in any part of any adequately ventilated room reasonably free from drafts. The temperature of the room is immaterial, but it shall not vary more than 20° F. during the test.

PROCEDURE

6. *Setting the Lamp.*—Clean the lamp and pour into the fount 850 cc. of the oil to be tested. Insert the wick in the burner, wet the wick with the oil, screw the burner firmly into the fount, and trim the wick with the scissors so as to produce a flame, which, unless otherwise specified by the buyer, shall be $1\frac{3}{4}$-in. high, measured from the top of the wick guide, and with a width, at the widest point, of $1\frac{3}{4}$ in. (See Fig. 1.) Trimming should be done very carefully to produce a smooth symmetrical flame free from peaks or ears, and the lamp should be lit and the flame inspected from time to time during the course of the trimming in order to determine whether the trim is satisfactory. Proper height can be obtained by turning the wick up or down and the proper width by trimming the corners of the wick. These adjustments should be made to $\pm \frac{1}{16}$ in. from the standard flame dimensions. Allow the lamp to burn one hour and then readjust the flame, if necessary, to the standard dimensions. At the end of the first hour, weigh the lamp, while burning, on a platform balance accurate to one gram, and weigh again after exactly sixty minutes further burning. Calculate the oil consumed in cubic centimeters per hour. The initial rate of oil consumption, thus established, shall not vary from 43 cc. per hour by more than ± 2 cc. With proper attention to flame dimensions this measurement is needed only as a check, since with a given flame size and shape the initial rate of oil consumption will always be within the limits set.

7. *Conducting the Test.*—Allow the oil to burn continuously without further adjustment of any kind for the duration of the test. Refill the lamp to within ¼ in. of the top of the fount, without putting out the flame, at intervals of eight hours.

8. *Duration of the Test.*—Unless otherwise specified by the buyer the duration of the test shall be 24 hours of continuous burning.

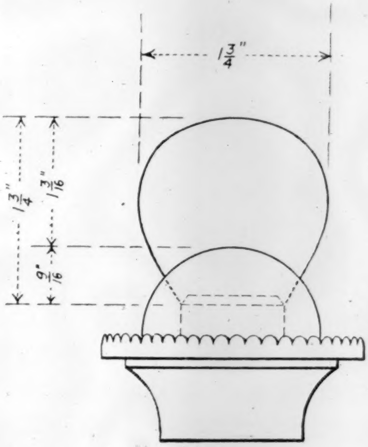

FIG. 1.—Illustration of Flame

9. *Interpretation.*—At the end of the test, note the height and width of the flame, and the condition of the chimney, flame and wick. The final flame measurements shall be taken without re-filling the lamp. The condition of the chimney, flame, and wick at the end of the test shall be in accordance with the requirements specified by the buyer, or, in case the buyer does not specify these points the condition shall be in accordance with such requirements as the manufacturer of the oil may consider desirable.

REPORT OF SUB-COMMITTEE XX ON NOMENCLATURE

The sub-committee has prepared definitions for the terms "crude petroleum," "weathered crude," "benzine," "petroleum naphtha," "gasoline," and "petroleum spirits" as follows:

Crude Petroleum (Crude Oil, Petroleum, Crude).—A naturally occurring mixture, consisting predominantly of hydrocarbons, which is removed from the earth in liquid state or is capable of being so removed.

NOTE.—Crude petroleum is commonly accompanied by varying quantities of extraneous substances such as water, inorganic matter and gas. The removal of such extraneous substances alone does not change the status of the mixture as crude petroleum. If the removal of such extraneous substances also results in the removal of more than a trace of the naturally occurring mixture, the resulting product is no longer crude petroleum.

Weathered Crude.—A crude petroleum from which a perceptible quantity of the more volatile constituents has evaporated.

Benzine.—This term is archaic and misleading and should not be used.

Petroleum Naphtha.—A generic term applied to refined or unrefined petroleum products and liquid products of natural gas, at least 95 per cent of which distill below 500° F. when distilled in accordance with the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 - 21 T) of the American Society for Testing Materials.[1]

Gasoline.—A refined petroleum naphtha which by its composition is suited as a carburant for internal combustion engines.

Petroleum Spirits.—A refined petroleum naphtha, with a minimum flash point of 70° F. (Tag Closed Tester, A.S.T.M. Standard) with a volatility and other properties making it suitable as a thinner and solvent in paints, varnishes and similar products.

NOTE.—The use of the term "turpentine substitute" is to be condemned as false and misleading. The term "mineral spirits" also should not be used as it includes within its scope not only petroleum products, but other hydrocarbon mixtures, such as coal-tar distillates.

It is not recommended at this time that these definitions be published by the Society as tentative but they are being presented as information with the hope that constructive criticism and suggestion will be received. The sub-committee particularly desires that such suggestions and criticisms be sent to the secretary of Committee D-2 prior to January 1, 1924.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 21, p. 631 (1921).

Respectfully submitted on behalf of the sub-committee,

K. G. MACKENZIE,
Chairman.

ADDENDUM TO REPORT OF COMMITTEE D-2

At a meeting of Committee D-2, held in Atlantic City on June 28, Mr. W. H. Fulweiler, chairman of Committee D-15 on Thermometers, presented to Committee D-2 proposed Tentative Specifications for A.S.T.M. Thermometers for Use with Saybolt Viscosimeter. These specifications had been prepared by Committee D-15 at the request of Committee D-2, but had not been presented to the committee in time for inclusion in the committee's report to the Society. Committee D-2 accordingly took action at the meeting to recommend to the Society the addition of these specifications to the Methods of Test for Viscosity by Means of the Saybolt Standard Universal Viscosimeter, appearing in the Standard Methods of Testing Lubricants (D 47 - 21),[1] and the Tentative Method of Test for Viscosity of Fuel Oils and Other Oils of Similar Viscosity (D 88 - 21 T),[2] and combining these two methods for the determination of viscosity by these instruments. The specifications for the thermometers will accordingly be found in the combined methods, submitted for publication as tentative, under the title "Tentative Method of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88 - 23 T)."[3]

Respectfully submitted,

C. P. Van Gundy,
Chairman.

K. G. Mackenzie,
Vice-Chairman.

Van H. Manning,
Secretary.

Editorial Note

The proposed revisions of the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products; for Flash and Fire Points by Means of Open Cup; for Cloud and Pour Points of Petroleum Products; and for Water in Petroleum Products, referred to in this report, were accepted. The tentative methods as thus revised appear on pages 665, 690, 698, and 694, respectively.

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 642 (1921).

[3] See p. 672.—Ed.

The proposed revisions of the method of test for viscosity by means of the Saybolt Universal viscosimeter appearing in the Standard Methods of Testing Lubricants as outlined in the Addendum to this report were accepted for publication with the revisions of the Tentative Method of Test for Viscosity of Fuel Oils and Other Oils of Similar Viscosity. The combined methods as thus revised appear on page 672.

The proposed Tentative Method of Test for Color of Lubricating Oils by Means of the Union Colorimeter; for Color of Refined Petroleum Oil by Means of Saybolt Chromometer; and for Steam Emulsion of Lubricating Oils; and the Tentative Methods of Testing Gas Oils, referred to in this report, were accepted for publication as tentative and appear on pages 677–689 and 703.

REPORT OF COMMITTEE D-4
ON
ROAD AND PAVING MATERIALS

Committee D-4 has held three meetings during the past year. It has given careful consideration to desirable changes in certain tentative and standard methods and specifications and has prepared a number of new methods and specifications which are offered for publication as tentative.

TENTATIVE SPECIFICATIONS RECOMMENDED FOR ADOPTION AS STANDARD

No. 1. The committee recommends that the following tentative specifications be advanced to standard without change:

(*a*) Tentative Specifications for Broken Slag for Waterbound Base and Wearing Course (D 65 – 20 T).[1]

(*b*) Tentative Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base (D 66 – 20 T).[2]

(*c*) Tentative Specifications for Block for Durax Granite Pavements (D 132 – 22 T).[3]

No. 2. *Tentative Specifications for Block for Recut Granite Block Pavements* (*D 131 – 22 T*).[4]—Attention is called to a typographical error in Section 4 where the depth of block specified as "4¼ to 5¼ in." should read "4¾ to 5¼ in." It is recommended that with the correction of this error and the addition of the following footnote, these specifications be advanced to standard:

> "The depth may be varied by the engineer between 4 and 5 in., depth of blocks to suit the old material, provided that the blocks used on any one contract shall not vary more than ¼ in. above or below the depth specified."

PROPOSED REVISIONS OF EXISTING STANDARD METHODS AND SPECIFICATIONS

No. 1. *Standard Method of Test for Softening Point of Bituminous Materials Other Than Tar Products* (*Ring-and-Ball Method*) (*D 36 – 21*).[5]—The committee recommends that the title of this standard method be changed by the omission of the words "Other Than Tar Products" as the test is applicable to certain tar products and is recommended for use in the proposed revision of a number of tentative specifications which are later mentioned in this report.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 698 (1920).

[2] *Ibid.*, p. 700.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 788 (1922).

[4] *Ibid.*, p. 786.

[5] 1921 Book of A.S.T.M. Standards.

No. 2. *Standard Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements* (*D 58 – 20*).[1]—The committee recommends that the following revisions of the standard specifications be published as tentative:

1. *Title.*—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

> "Standard Specifications for Materials for Cement Mortar Bed for Brick, Stone Block, [and] Wood Block, *Asphalt Block and Other Block* Pavements."

2. *Section 2.*—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "(*a*) The sand shall be well graded from coarse to fine and when tested [by means of a laboratory sieve] *for gradation as to size* shall meet the following [requirement] *requirements:*
>
> *Total passing $^{1}/_{4}$-in. screen*.................... *100* per cent
> Total passing 10-mesh sieve [100] *not less than* *90* "
>
> "(*b*) [This test] *These tests* shall be made in accordance with the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials, *with the exception that a $^{1}/_{4}$-in. screen conforming to the requirements given in the Standard Method of Mechanical Analysis of Mixtures of Sand or Other Fine Material with Broken Stone or Broken Slag, except Aggregates Used in Cement Concrete (Serial Designation: D 19 – 16) of the American Society for Testing Materials shall be used in addition to the others specified in Method D 7.*"

3. *Section 3.*—Change the side heading of Section 3 from "Mortar Strength Test" to "Mortar Strength" and change Paragraph (*a*) to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "(*a*) [When the sand is] *The sand shall be passed through a 10-mesh sieve and that portion retained by the 10-mesh sieve shall be discarded. The portion passing a 10-mesh sieve shall be* mixed with portland cement [passing] *conforming to* the requirements of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials, in the proportion of 1 part cement to 3 parts of sand, by weight, according to the standard method of making 1 : 3 mortar briquettes. The resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least 75 per cent of that developed in the same time by mortar of the same consistency, made of 1 part of the same cement and 3 parts of Ottawa sand."

PROPOSED TENTATIVE METHODS RECOMMENDED AS SUBSTITUTES FOR EXISTING STANDARDS OR TENTATIVE STANDARDS

No. 1. *Standard Method of Test for Soluble Bitumen* (*D 4 – 11*).[1]—Since this method has proved to be too time consuming for general use, the committee recommends that it be superseded by the Proposed Method of Test for the Determination of Bitumen appended hereto[1] for publication as tentative.

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[1] 1921 Book of A.S.T.M. Standards.

No. 2. *Tentative Method of Test for Water in Bituminous Materials (D 114 - 21 T).*[2]—During the past year, Committee D-4 has cooperated with other committees in the work of the Sub-Committee on Water in Bituminous Materials of Committee E-1 on Methods of Testing which has prepared a Method of Test for Water in Petroleum Products and Other Bituminous Materials. As a result Committee D-4 joins with Committee D-2 on Petroleum Products and Lubricants and Committee D-7 on Timber in recommending that this method be published as tentative as appended to the report of Committee D-2. In the event of its acceptance as tentative, Committee D-4 considers it a substitute for the present Tentative Method of Test for Water in Bituminous Materials (D 114 - 21 T) and recommends that the latter be withdrawn.

PROPOSED REVISIONS OF TENTATIVE SPECIFICATIONS AND METHODS OF TEST

No. 1. *Tentative Method of Mechanical Analysis of Subgrade Soils (D 137 - 22 T).*[3]—The following changes are recommended:

Section 4.—Change the first sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "[A 25-g. sample of soil passing the 10-mesh sieve and prepared as specified in Section 2 shall be] *By the method of quartering, a sample weighing approximately 25 g. shall be selected and* placed in a beaker with approximately 500 cc. of distilled water, gradually brought to the boiling point and shall then be allowed to stand for about 24 hours."

Change the fourth sentence to read as follows by the addition of the italicized words:

> "The supernatant liquid shall then be decanted *to a depth of 8 cm. from the surface of the liquid* into a vessel having a capacity of about 10 liters."

The committee recommends that the method, as revised, be continued as tentative.

No. 2. *Tentative Method of Float Test for Bituminous Road Materials (D 139 - 22 T).*[4]—The following changes are recommended:

Section 1.—Change the minimum, normal and maximum thickness of shoulder of the float now reading 1.2, 1.4, and 1.6 mm., to read 1.3, 1.4 and 1.5 mm., respectively.

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[1] See p. 751.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 706 (1921).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 803 (1922).

[4] *Ibid.*, p. 809.

Change the minimum, normal and maximum diameter of opening in the float now reading 10.7, 11.1 and 11.5 mm., to read 11.0, 11.1 and 11.2 mm., respectively.

Section 2.—Add a sentence to read as follows:

"The top of the collar shall screw up tightly against the lower side of the shoulder."

Figure 1.—Change the diameter of the float now reading "92.92 mm." to read "93 ± 1 mm." Change the location of threads to show them beginning 3 mm. from the top of the collar. Shift the dimension line to show the *lower* side of shoulders 27 mm. below the rim to agree with the requirements. Make the radius of the float an *outside* dimension of 53.6 mm. and omit the thickness dimension at the rim. Shift the words "Taper to make weight" to half way up the side on the *inside* of the float. Indicate "Thickness of Shoulder 1.4 mm." at the opening. Change the thread from "left hand" to "right hand".

The committee recommends that the method as revised be continued as tentative.

No. 3. *Tentative Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction (D 63 - 20 T).*[1]—The following changes are recommended:

Section 4.—In the table showing the maximum permissible range in mechanical analysis for each size, change the requirement for the designated size $\frac{1}{4}$–$1\frac{1}{4}$ in. by omitting "3–10" in the first column and substitute therefor "0–5." In the third column change the requirement "65–85" for this size to "25–75".

The committee recommends that the specifications as revised be continued as tentative.

No. 4.—*Tentative Specifications for Asphalt Cement (D 99 - 22 T, D 100 - 22 T, D 101 - 22 T, D 102 - 22 T, D 103 - 22 T, D 133 - 22 T, D 134 - 22 T, D 135 - 22 T).*[2] The committee recommends that each of the eight tentative specifications for asphalt cement be amended as follows, and that the specifications as revised be continued as tentative:

"*Section 1.*—Combine Paragraphs (*c*) and (*d*) making a new Paragraph (*c*) to read as follows, re-lettering the subsequent paragraphs accordingly:

"(*c*) Loss on Heating at 163° C. (325° F.), 50 g.,
5 hr. . . . . .not more than ....[3] per cent

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 693 (1920).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, pp. 792–799 (1922).

[3] In the case of Specifications D 99, D 100, D 101, D 102, D 103 and D 135, this value is 2; in the case of Specifications D 133 and D 134, it is 1.

Penetration at 25° C. (77° F.), 100 g., 5 sec.,
of residue after heating at 163° C. (325° F.)
as compared with penetration of asphalt
cement before heating..................not less than ....[1] per cent"

Add a note at the end of the section to read as follows:

"NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported."

No. 5. *Tentative Specifications for High-Carbon Tar for Surface Treatment, Cold Application (D 104 - 21 T)*.[2]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar shall conform to the following requirements:
(a) Water................................not more than 2.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.)..............1.14 to 1.18]
[c] (*b*) Specific viscosity, Engler, 50 cc. at 40° C. (104° F.) ......8 to [20] *35*
[d] (*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C.
(32 to 338° F.)............. not more than 7.00 per cent
Total Distillate, by weight, 0 to 235° C.
(32 to 455° F.).............not more than [18.00] *20.00* "
Total Distillate, by weight, 0 to 270° C.
(32 to 518° F.).............not more than [28.00] *30.00* "
Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.)............. not more than 35.00 "
Residue, by weight............. not less than 65.00 "

[e] (*d*) Specific gravity at 25°/25° C. (77°/77° F.) of total
distillate to 300° C. (572° F.).................not less than 1.01
[f] (*e*) Softening point ([Cube-in-Water Method] *Ring-and-Ball Method*) of residue from distillation
test............not more than 60° C. (140° F.)
[g] (*f*) [Free carbon.] *Total Bitumen* (*Soluble in Carbon Disulfide*)...........[4.00 to 12.00 per cent] *88.00 to 97.00 per cent.*"

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

"All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

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[1] In the case of Specifications D 99, D 100, D 101, D 102, D 103 and D 135, this value is 60; in the case of Specifications D 133 and D 134, it is 50.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 686 (1921).

Footnote 2.—Change the second sentence to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "It is recommended that [a permissible range of 5 be given, and that] materials be called for under the following *range and* headings; Light 8–13, medium [11–16] *13–18*, heavy [15–20] *18–25, extra heavy 25–35*."

Section 2.—Omit the reference to the method for determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 6. *Tentative Specifications for Low-Carbon Tar for Surface Treatment, Cold Application (D 105 – 21 T).*[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar shall conform to the following requirements:
(a) Water.................................not more than 2.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.)...............1.10 to 1.14]
[c] (*b*) Specific viscosity, Engler, 50 cc. at 40° C. (104° F.)......[20] *8* to 35
[d] (*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C.
(32 to 338° F.)..............not more than [2.00] *5.00* per cent
Total Distillate, by weight, 0 to 235° C.
(32 to 455° F.).............not more than [15.00] *20.00* "
Total distillate, by weight, 0 to 270° C.
(32 to 518° F.) .... not more than [30.00] *35.00* "
Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.).............not more than [40.00] *45.00* per cent
Residue, by weight............ not less than [60.00] *55.00* "

[e] (*d*) Softening point ([Cube-in-Water Method] *Ring-and-Ball Method*) of residue from distillation test.............not more than [70° C. (158° F.)] *60° C. (140° F.)*
[f] (*e*) [Free carbon] *Total Bitumen (Soluble in Carbon Disulfide)*....[not more than 5.00 per cent] *not less than 95.0 per cent*"

Add a footnote reference to the word "requirements" in the first line, the footnote to read as follows:

> "All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 688 (1921).

Footnote 2.—Change the second sentence to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "It is recommended that [a permissible range of 5 be given and that] materials be called for under the following *range and* headings: Light [20–25] *8–13*, medium [25–30] *13–18*, heavy [30–35] *18–25*, *extra heavy 25–35*."

Section 2.—Omit the reference to the method for determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 7. *Tentative Specifications for High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 106 – 21 T).*[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar cement shall conform to the following requirements:

(a) Water. . . . . .not more than 2.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.). . . . . .1.15 to 1.20]
[c] (*b*) Specific viscosity, Engler, 50 cc. at 40° C. (104° F.). .[40 to 70] *35 to 80*
[d] (*c*) Distillation test on water-free material:
Total Distillate, by weight, 0 to 170° C.
(32 to 338° F.). . . . . [4.00 to 12.00] *3.00 to 10.00* per cent
Total Distillate, by weight, 0 to 235° C.
(32 to 455° F.). . . . . 8.00 to 20.00 "
Total Distillate, by weight, 0 to 270° C.
(32 to 518° F.). . . . . 18.00 to 30.00 per cent
Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.). . . . . .not more than 35.00 "
Residue, by weight. . . . . .not less than 65.00 "

[e] (*d*) Softening point ([Cube-in-Water Method] *Ring-and-Ball Method*) of residue from distillation test. . . . . .not more than [75° C. (167° F.)] *65° C. (149° F.)*
[f] (*e*) [Free carbon] *Total Bitumen (Soluble in Carbon Disulfide)*. . . . .[12.00 to 22.00 per cent] *78.00 to 95.00 per cent*"

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

> "All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 690 (1921).

Add a footnote reference to the requirement for specific viscosity, the footnote to read as follows:

"It is recommended that materials be called for under the following range and headings: Light 35 to 60, heavy 60 to 80. The heavy material may require heating before use, and care should be taken to avoid foaming on account of the possible water content."

Add a footnote reference to the requirement for total bitumen, the footnote to read as follows:

"The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified."

Section 2.—Omit the reference to the method for determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 8.—*Tentative Specifications for Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 107 – 21 T).*[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar cement shall conform to the following requirements:

(a) Water..............................not more than 2.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.)..............1.09 to 1.15]
[c] (*b*) Specific viscosity, Engler, 50 cc. at 40° C. (104° F.)..[35 to 45] *35 to 80.*
[d] (*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C.
(32 to 338° F.)......[not more than 3.00] *3.00 to 10.00* per cent
Total Distillate, by weight, 0 to 235° C.
(32 to 455° F.)......[not more than 20.00] *8.00 to 20.00* "
Total Distillate, by weight, 0 to 270° C.
(32 to 518° F.)......[not more than 30.00] *18.00 to 30.00* "
Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.)......not more than [40.00] *38.00* "
Residue, by weight...... not less than [60.00] *62.00* "

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 692 (1921).

[e] (*d*) Softening point ([Cube-in-Water] *Ring-and-Ball* Method) of residue from distillation test .... not more than [75° C. (167° F.)] *65° C. (149° F.)*
[f] (*e*) [Free carbon] *Total Bitumen (Soluble in Carbon Disulfide)*.........[not more than 5.00] *not less than 95.00 per cent*"

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

> "All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

Add a footnote reference to the requirement for specific viscosity, the footnote to read as follows:

> "It is recommended that materials be called for under the following range and headings: Light 35 to 60, heavy 60 to 80. The heavy material may require heating before use, and care should be taken to avoid foaming on account of the possible water content."

Section 2.—Omit the reference to the method for determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 9. *Tentative Specifications for High-Carbon Tar for Surface Treatment, Hot Application (D 108 – 21 T).*[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar shall conform to the following requirements:

(a) Water...0.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.)..............1.20 to 1.26]
[c] (*b*) Float test at 32° C. (89.6° F.).........................60 to 150 sec.
[d] (*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than [0.00] 1.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 10.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 15.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 25.00	"
Residue, by weight	not less than 75.00	"

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 694 (1921).

[e] (*d*) Specific gravity at 25° C. (77° F.) of total distillate to 300° C. (572° F.)....................not less than 1.03
[f] (*e*) Softening point ([Cube-in-Water] *Ring-and-Ball* Method) of residue from distillation test.......................not more than [75° C. (167° F.)] *65° C. (149° F.)*
[g] (*f*) [Free carbon] *Total Bitumen (Soluble in Carbon Disulfide)*................[12.00 to 22.00] *78.00 to 95.00* per cent."

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

"All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

Add a footnote reference to the requirement for total bitumen, the footnote to read as follows:

"The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified."

Section 2.—Omit the reference to the method for determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 10. *Tentative Specifications for Low-Carbon Tar for Surface Treatment, Hot Application (D 109 – 21 T).*[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 1.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar shall conform to the following requirements:
(a) Water..0.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.)...............1.14 to 1.18]
[c] (*b*) Float test at 32° C. (89.6° F.)........................60 to 150 sec.
[d] (*c*) Distillation test:
Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)....................not more than [0.00] 1.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)....................not more than 4.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)....................not more than 13.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)....................not more than 26.00 "
Residue, by weight....................not less than 74.00 "

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 696 (1921).

[e] (*d*) Softening point ([Cube-in-Water] *Ring-and-Ball*
Method) of residue from distillation test.......
..................not more than [75° C. (167° F.)] *65° C. (149° F.)*
[f] (*e*) [Free carbon] *Total Bitumen (Soluble in Carbon*
Disulfide)..[not more than 5.00 per cent] *not less than 95.00 per cent.*"

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

> "All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

Section 2.—Omit the reference to the method for determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 11. *Tentative Specifications for High-Carbon Tar Cement (D 110 – 21 T).*[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 2.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar cement shall conform to the following requirements:
(a) Water..0.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.)..............1.20 to 1.28]
[c] (*b*) Softening point ([Cube-in-Water] *Ring-and-Ball*
Method)...[37.5 to 48.9° C. (100 to 120° F.)] *30 to 40° C. (86 to 104° F.)*
[d] (*c*) Distillation test:
Total Distillate, by weight, 0 to 170° C.
(32 to 338° F.)....................not more than [0.00] 1.00 per cent
Total Distillate, by weight, 0 to 235° C.
(32 to 455° F.)....................not more than 2.00 "
Total Distillate, by weight, 0 to 270° C.
(32 to 518° F.)....................not more than 10.00 "
Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.)....................not more than 20.00 "
Residue, by weight.................... not less than 80.00 "

[e] (*d*) Specific gravity at 25°/25° C. (77°/77° F.) of total
distillate to 300° C. (572° F.)....................not less than 1.03
[f] (*e*) Softening point ([Cube-in-Water] *Ring-and-Ball*
Method) of residue from distillation test.......
..................not more than [75° C. (167° F.)] *65° C. (149° F.)*
[g] (*f*) [Free carbon] *Total Bitumen (Soluble in Carbon*
Disulfide) ....[12.00 to 25.00 per cent] *78.00 to 95.00 per cent.*"

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21. p. 698 (1921).

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

"All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

Add a footnote reference to the requirements for total bitumen, the footnote to read as follows:

"The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified."

Footnote 3.—Change to read as follows:

"The specification range for softening point, within the above limits, should be 5° C. for any given locality. For example 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 seconds; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 seconds."

Section 3.—Omit the reference to the method for determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 12. *Tentative Specifications for Low-Carbon Tar Cement (D 111 – 21 T).*[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 2.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The tar cement shall conform to the following requirements:
(a) Water..0.00 per cent
[(b) Specific gravity at 25°/25° C. (77°/77° F.)..............1.16 to 1.19]
[c] *(b)* Softening point [(Cube-in-Water)] *(Ring-and-Ball* Method). . [37.5 to 48.9° C. (100 to 120° F.] *30 to 40° C. (86 to 104° F.)*
[d] *(c)* Distillation test:
Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)....................not more than [0.00] 1.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)....................not more than 2.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)....................not more than 10.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)....................not more than 20.00 "
Residue, by weight.................... not less than 80.00 "

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 700 (1921).

[e] (*d*) Softening point [(Cube-in-Water)] (*Ring-and-Ball Method*) of residue from distillation test. . . . . .not more than [75° C. (167° F.)] *65° C. (149° F.)*

[f] (*e*) [Free Carbon] *Total Bitumen (Soluble in Carbon Disulfide*. . . .[not more than 5.00 per cent] *not less than 95 per cent.*"

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

"All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

Footnote 3.—Change to read as follows:

"The specification range for softening point, within the above limits, should be 5° C. for any given locality. For example 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 seconds; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 seconds."

Section 3.—Omit the reference to the method of determining specific gravity and change the reference for the method of determining softening point from the Cube-in-Water Method to the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36 – 21).

No. 13. *Tentative Specifications for Coal-Tar Pitch for Stone Block Filler* (*D 112 – 22 T*).[1]—The committee recommends the following changes in these specifications, and further recommends that the specifications as revised be continued as tentative:

Section 1.—Omit Paragraph (*b*) covering the requirement of specific gravity, reading as follows, re-lettering the subsequent paragraphs accordingly:

"(b) Specific Gravity at 25°/25° C. (77°/77° F.). . . . . .1.23 to 1.33"

Change Paragraph (*h*) from its present form: namely,

"Free carbon. . . . . .20 to 35.00 per cent"

to read as follows:

"Total Bitumen (Soluble in Carbon Disulfide). . .65.00 to 80.00 per cent"

Add a footnote reference to the word "requirements" in the first line of the section, the footnote to read as follows:

"All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis."

Section 2.—Omit the reference to the method for determining specific gravity.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 800 (1922).

No. 14. *Tentative Specifications for Natural or Artifical Sand-Clay Mixtures for Highway Surfacing (D 67 - 20 T)*.[1] These specifications have been completely revised, and are appended hereto in their proposed revised form.[2]

NEW METHODS OF TEST AND SPECIFICATIONS SUBMITTED AS TENTATIVE

No. 15. The committee recommends the following specifications and methods of test, appended hereto,[3] for publication as tentative:

(*a*) Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride.

(*b*) Specifications for Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete.

(*c*) Specifications for Asphalt Cement, 30 to 40 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete.

(*d*) Specifications for Broken Slag for Bituminous Macadam Wearing Course.

(*e*) Specifications for Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type).

(*f*) Specifications for Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type).

(*g*) Specifications for Sand for Sheet Asphalt and Bituminous Concrete Pavements.

COMBINATION OF TENTATIVE METHODS OF SAMPLING BITUMINOUS MATERIALS

During the past year representatives of Committee D-8 on Waterproofing Materials and Committee D-4 were appointed to prepare if possible a combination of the Tentative Methods of Sampling Bituminous Materials proposed by these committees in 1922 under serial designations D 148 - 22 T and D 140 - 22 T, respectively. Such a combination satisfactory to both committees was effected by adopting the methods which had been recommended by Committee D-4 with a rewording of Section 12 and the insertion of a new Section 13. It is accordingly recommended that the Tentative Methods of Sampling Bituminous Materials (D 140 - 22 T)[4] be revised as follows:

Section 12.—Change from its present form: namely,

"(*a*) Samples of liquid bituminous materials from barrels or drums may be secured by taking 1 qt. of material from one out of every ten packages, combining and thoroughly mixing these samples and then removing an average sample from the combined material.

(*b*) Sampling of solid or semi-solid materials from barrels is more difficult to accomplish properly. It is recommended that samples be taken from each car lot, but if this sample fails to meet the specification requirements, then a sample shall be taken from each batch represented or from one out of each twenty barrels, samples to be taken from at least 3 in. below the surface and at least 3 in. from the side of the barrel. A clean hatchet may be used if the material is hard enough to shatter and a broad stiff putty knife if the material is soft. The samples so taken shall be melted and thoroughly mixed and an average sample taken from the combined material for examination."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 702 (1920).

[2] See p. 718.—ED.

[3] See pp. 712–717, 721–723, 754.—ED.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 812 (1922).

to read as follows:

"12. *Barrels, Drums and Cakes.*—(*a*) *Semi-Solid or Solid Materials.*—Where the lot of material to be sampled is obviously from a single run or batch of the producer, one package or cake shall be selected at random and sampled as described in the following paragraph. Where the lot of material to be sampled is not obviously from a single run or batch of the producer, or where the single sample selected as described above fails on test to conform to the requirements of the specifications, a number of packages or cakes shall be selected at random equivalent to the cube root of the total number of packages or cakes in the lot. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

PACKAGES OR CAKES IN SHIPMENT	PACKAGES OR CAKES SELECTED	PACKAGES OR CAKES IN SHIPMENT	PACKAGES OR CAKES SELECTED
2 to 8	2	217 to 343	7
9 to 27	3	344 to 512	8
28 to 64	4	513 to 729	9
65 to 125	5	730 to 1000	10
126 to 216	6	1001 to 1331	11,

"Samples shall be taken from at least 3 in. below the surface and at least 3 in. from the side of the container or cake or from the center of a cake. A clean hatchet may be used if the material is hard enough to shatter and a broad stiff putty knife if the material is soft. An auger, or brace and $\frac{3}{4}$-in. bit, or other suitable means may also be used. When more than one package or cake in a lot is sampled, each individual sample shall be not less than $\frac{1}{4}$ lb. in weight. When the lot of material is obviously from a single run or batch of the producer, all samples from the lot shall be melted and thoroughly mixed, and an average sample taken from the combined material for examination. In case more than a single run or batch of the producer is present and the batches can be clearly differentiated a composite sample shall be prepared for examination from each batch. Where it is not possible to differentiate between the various batches, each sample shall be examined separately.

"(*b*) *Liquid Materials.*—Samples of liquid bituminous materials from barrels or drums shall be secured by taking 1 qt. of material from packages selected at random according to the cube root method described in Paragraph (*a*). When the lot of material is obviously from a single run or batch of the producer the samples shall be combined and thoroughly mixed and an average sample taken from the combined material. In case more than one run or batch is present and can be clearly differentiated a composite sample shall be prepared from each batch. Where it is impossible to differentiate between the various batches or runs, each sample shall be examined separately."

Add a new Section 13 to read as follows:

"13. *Bulk and Bags.*—Solid bituminous materials in crushed fragments or powder, such as gilsonite, grahamite, etc., shall be sampled in accordance with the Standard Method of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials."

The results of the letter ballot of the committee upon the recommendations which have been made in this report are as follows:

Items	Affirmative	Negative	Not Voting
I. TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD			
Tentative Specifications for Broken Slag for Waterbound Base and Wearing Course (D 65 - 20 T)	35	1	22
Tentative Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base (D 66 - 20 T)	33	1	24
Tentative Specifications for Block for Durax Granite Pavements (D 132 - 22 T)	33	1	24
Tentative Specifications for Block for Recut Granite Block Pavements (D 131 - 22 T) as amended	33	1	24
II. PROPOSED REVISION OF EXISTING STANDARD METHODS AND SPECIFICATIONS			
Standard Method of Test for Softening Point of Bituminous Materials Other Than Tar Products (Ring-and-Ball Method) (D 36 - 21)	40	0	18
Standard Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements (D 58 - 20)	36	0	22
III. PROPOSED TENTATIVE METHODS RECOMMENDED AS SUBSTITUTE FOR EXISTING STANDARDS OR TENTATIVE STANDARDS			
Standard Method of Test for Soluble Bitumen (D 4 - 11)	43	0	15
Tentative Method of Test for Water in Bituminous Materials (D 114 - 21 T)	39	0	19
Tentative Specifications for Natural or Artificial Sand-Clay Mixtures for Highway Surfacing (D 67 - 20 T)	33	2	23
IV. PROPOSED REVISIONS OF EXISTING TENTATIVE STANDARDS			
Tentative Method of Mechanical Analysis of Sub-grade Soils (D 137 - 22 T)	36	0	22
Tentative Method of Float Test for Bituminous Road Materials (D 139 - 22 T)	39	0	19
Tentative Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction (D 63 - 20 T)	38	2	18
Tentative Specifications for Asphalt Cement (D 99 - 22 T) (D 100 - 22 T) (D 101 - 22 T) (D 102 - 22 T) (D 103 - 22 T) (D 133 - 22 T) (D 134 - 22 T) (D 135 - 22 T)	36	1	21
Tentative Specifications for High-Carbon Tar for Surface Treatment, Cold Application (D 104 - 21 T)	32	1	25
Tentative Specifications for Low-Carbon Tar for Surface Treatment, Cold Application (D 105 - 21 T)	31	1	26
Tentative Specifications for High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 106 - 21 T)	32	1	25
Tentative Specification for Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product) (D 107 - 21 T)	31	1	26
Tentative Specifications for High-Carbon Tar for Surface Treatment, Hot Application (D 108 - 21 T)	32	1	25
Tentative Specifications for Low-Carbon Tar for Surface Treatment, Hot Application (D 109 - 21 T)	31	1	26
Tentative Specifications for High-Carbon Tar Cement (D 110 - 21 T)	32	1	25
Tentative Specifications for Low-Carbon Tar Cement (D 111 - 21 T)	32	1	25
Tentative Specifications for Coal-Tar Pitch for Stone Block Filler (D 112 - 22 T)	28	2	28
V. PROPOSED NEW TENTATIVE STANDARDS			
Proposed Tentative Method of Test for the Determination of Proportion of Bitumen Insoluble in Carbon Tetrachloride	38	0	20
Proposed Tentative Specifications for Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements	35	3	20
Proposed Tentative Specifications for Asphalt Cement, 30 to 40 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements	35	3	20
Proposed Tentative Specifications for Broken Slag for Bituminous Macadam Wearing Surface	35	2	21
Proposed Tentative Specifications for Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type)	35	2	21
Proposed Tentative Specifications for Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type	34	3	21
Proposed Tentative Specifications for Sand for Sheet Asphalt and Bituminous Concrete Pavements	35	5	18
VI. PROPOSED COMBINATION OF EXISTING TENTATIVE STANDARD			
Proposed Combination of Tentative Methods of Sampling Bituminous Materials Shipped in Barrels or Drums (D 148 - 22 T) and Tentative Method of Sampling Bituminous Materials (D 140 - 22 T)	41	0	17

This report has been submitted to letter ballot of the committee, which consists of 58 members, of whom 44 have voted affirmatively, none negatively, and 14 have refrained from voting.

Respectfully submitted on behalf of the committee,

PRÉVOST HUBBARD,
Secretary.

F. P. SMITH,
Chairman.

ADDENDUM TO REPORT OF COMMITTEE D-4

At a meeting of Committee D-4 held on June 27 action was taken to recommend a revision of the Standard Methods of Test for Apparent Specific Gravity of Sand, Stone and Slag Screenings and Other Fine Non-Bituminous Highway Materials (D 55 – 19)[1] as follows:

Section 4.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "The determination shall be made with [a] *the* Jackson specific gravity apparatus (illustrated in Fig. 2) which shall consist of a burette, with graduations reading to [0.01] *0.02* in specific gravity, about [23 cm. (9 in.)] *28 cm. (11 in.)* long and with an inside diameter of about [0.6 cm. (0.25 in.)] *0.7 cm (0.3 in.)*, which shall be connected with a glass bulb approximately 13 cm. (5¼ in.) long and 4.5 cm. (1.75 in.) in diameter, the glass bulb being of such size that from a mark on the neck [at the top to a mark on the burrette just below the bulb, the capacity is exactly 180 cc. (6.09 liquid oz.)] *above the bulb to the top graduation on the burrette, the capacity shall be such that the graduations shall read directly the specific gravity when 50 g. of material are used;* and an Erlenmeyer flask, which shall contain a hollow ground-glass stopper having [the] *a* neck of [the same bore as the burrette, and] *approximately 6 to 8 mm. bore and which* shall have a capacity of exactly 200 cc. (6.76 oz.) up to the graduation on the neck of the stopper.

EDITORIAL NOTE

The Tentative Specifications for Block for Recut Granite Block Pavements, amended as indicated in this report; and the Tentative Specifications for Broken Slag for Waterbound Base and Wearing Course; for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base; and for Block for Durax Granite Pavements were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

The proposed revisions of the Standard Specifications for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements were acepted for publication as tentative and appear on page 968. The proposed revision of the Standard Method of Test for Soluble Bitumen was accepted for publication as a new tentative method, entitled "Tentative Method of Test for the Determination of Bitumen," and appears on page 751.

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[1] 1921 Book of A.S.T.M. Standards.

The proposed revisions of the Standard Methods of Test for Apparent Specific Gravity of Sand, Stone and Slag Screenings, as outlined in the Addendum to this report, were accepted for publication as tentative and appear on page 970.

The proposed revisions of the 19 tentative specifications listed in items Nos. 3 to 14 of this report were accepted. The specifications as thus revised appear on pages 709, 718–720, and 725–748. The proposed revisions of the Tentative Methods of Mechanical Analysis of Subgrade Soils; of the Tentative Method of Float Test for Bituminous Road Materials; and of the Tentative Methods of Sampling Bituminous Materials, referred to in this report, were accepted. The methods as thus revised appear on pages 749 and 756–762, respectively

The 7 proposed new tentative standards referred to in item No. 15 of this report were accepted for publication as tentative and appear on pages 712–717, 721–724, and 754.

The withdrawal, recommended in this report, of the Tentative Method of Test for Water in Bituminous Materials was approved.

REPORT OF COMMITTEE D-5

ON

COAL AND COKE

Committee D-5 held three meetings during the past year. At the first meeting, held June 28, 1922, at Atlantic City, N. J., it was considered advisable to combine Committee D-5 on Coal and Committee D-6 on Coke, as the interests of these two committees were so closely related. Similar action was taken by Committee D-6 on Coke at a meeting held June 28, 1922, at Atlantic City, N. J. This combination has been approved by the Executive Committee of the Society and the combined committee is known as Committee D-5 on Coal and Coke.

Experimental work has been conducted on a method for determining fineness of pulverized coal, and will be continued next year. A method for the determination of percentage by volume of cell-space of lump coke has been standardized. Combustibility tests have been conducted on different cokes in an experimental furnace, and an analysis of about one hundred boiler tests on semi-bituminous coals in regard to clinker trouble as related to laboratory tests of ash fusibility have been made. Specifications for Gas and Coking Coals have been prepared and progress has been made in the standardization of anthracite sizes.

Tentative Method of Test for Fusibility of Coal Ash (D 22 - 22 T).[1]—The Tentative Method of Test for Fusibility of Coal Ash was issued in 1919 and revised in 1922. The committee, after having given careful consideration to other methods, recommends the method to the Society for adoption as standard.

Tentative Method of Shatter Test for Coke (D 141 - 22 T).[2]—No criticisms of the Tentative Method of Shatter Test for Coke (D 141 - 22 T) have been received. Committee D-5 therefore recommends it to the Society for adoption as standard with the following minor revisions:

Section 1.—Add a sentence to read as follows:

"A convenient form of shatter test machine is shown in Fig. 1."

Section 3.—Add a new Section 3 to read as follows, re-numbering the subsequent sections accordingly:

"3. *Unit of Sampling.*—Each carload, or its equivalent, shall be considered a unit for sampling."

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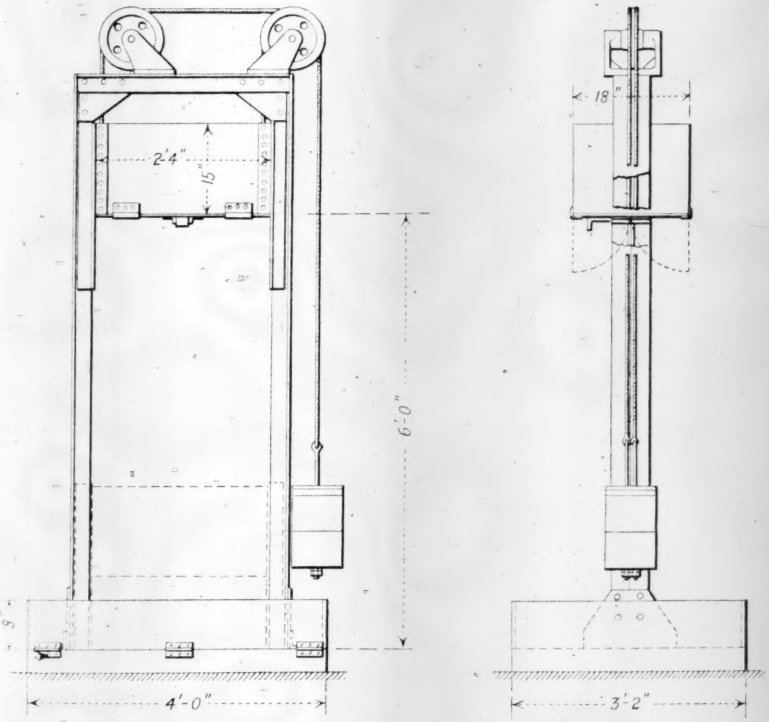
[1] *Proceeding*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 815 (1922).

[2] *Ibid.*, p. 822.

Porosity of Coke.—Sub-Committee I on Methods of Testing, A. C. Fieldner, Chairman (part of a joint committee with the American Chemical Society, W. A. Noyes, Chairman), after considerable experimental work, standardized a method for determination by volume of cell-space of lump coke. At the present time methods are being used for this determination which do not give comparable results. The committee believes that a standard method should be adopted for this determination and therefore recommends that the Proposed Tentative Method of Test for Volume of Cell Space of Lump Coke, appended hereto,[1] be accepted by the Society for publication as tentative.



Side Elevation

End Elevation.

FIG. 1.—Shatter Test Machine.

Fusibility of Coal Ash Coordination.—Mr. E. B. Ricketts, Chairman of a special Sub-Committee on Fusibility of Coal Ash Coordination, made an analysis of about one hundred boiler tests on coals from the semi-bituminous fields of Pennsylvania, West Virginia and

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[1] See p. 766.—ED.

Wales, with a view of correlating clinker trouble with laboratory tests on fusibility of coal ash.

The boiler tests were made on a 7 retort, 17 tuyere, hand-dump Taylor underfeed stoker. Most of these tests were run for about five hours at about 1000 h. p., and then at the maximum obtainable for one hour. The tests were practically all run by one man and based on his observations. The coals tested have been divided into three classes: namely, (1) those which gave no clinker trouble, (2) those which gave some clinker trouble but not enough to seriously interfere with operations, and (3) those which gave serious clinker trouble.

The following is a summary of the data obtained from the tests:

Fusion Temperature as Determined in the Laboratory	Class 1	Class 2	Class 3
Above 2500° F.	76 per cent	10 per cent	0 per cent
2400 to 2500° F.	14 "	44 "	41 "
2300 to 2400° F.	10 "	34 "	55 "
2200 to 2300° F.	0 "	6 "	4 "
2100 to 2200° F.	0 "	6 "	0 "

From the above tests it appears that coals having an ash fusion temperature above 2500° F. will not give serious clinker trouble with the type of stoker equipment on which the tests were made. It is to be noted that many of the coals of low ash fusibility did not give serious clinker trouble.

Other factors besides the fusion temperature of the ash are evidently important factors on which clinker trouble depends. Some of these factors to be investigated are (1) caking qualities, (2) manner in which the ash-forming material exists in the coal, (3) manner in which ash-forming material conglomerates, (4) temperature of fuel bed, (5) length of time ash is subjected to this temperature, (6) size of particles, and (7) association of particles in the ash.

Nomenclature and Definitions.—Sub-Committee II, H. C. Porter, Chairman, has given careful consideration to the method best suitable for reporting ultimate analyses of coal, and specific recommendations will be made next year. The sub-committee, in cooperation with Committee E-8 on Nomenclature and Definitions, has considered certain modifications in the Tentative Definitions of Terms Relating to Coke (D 121 - 21 T) and of the Tentative Definitions of Terms Relating to Coal (D 142 - 22 T). These proposed modifications of the definitions will be presented to the Society next year. In view of the fact that changes in these tentative definitions are to be made, it is recommended that they be continued as tentative for another year.

Specifications for Gas and Coking Coals.—Sub-Committee III, O. O. Malleis, Chairman, in conjunction with a committee of the American Gas Association and Sub-Committee II on Nomenclature and Definitions, prepared specifications for gas and coking coals. These specifications give the limits within which gas and coking coals will usually fall, and indicate the circumstances under which further restrictive conditions should be imposed. It is recommended that the Proposed Tentative Specifications for Gas and Coking Coals, appended hereto,[1] be accepted by the Society for publication as tentative.

Standard Anthracite Sizes.—Sub-Committee IV, Hubb Bell, Chairman, has under consideration the standardization of anthracite sizes. The sub-committee has assembled considerable data and it is hoped to be able to present specific recommendations next year.

Sub-Committee on Increase of Society Membership.—In accordance with a request from the Executive Committee, Committee D-5 has organized a new sub-committee, known as Sub-Committee V, on Increase of Society Membership. The personnel of this sub-committee is as follows: W. A. Selvig, Chairman; Hubb Bell, and W. D. Langtry.

This report has been submitted to letter ballot of the committee, which consists of 43 members, of whom 38 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

H. C. PORTER,
Vice-Chairman.

W. A. SELVIG,
Secretary.

EDITORIAL NOTE

The Tentative Method of Shatter Test for Coke, amended as indicated in this report; and the Tentative Method of Test for Fusibility of Coal Ash were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

The proposed Tentative Specifications for Gas and Coking Coals; and the proposed Tentative Method of Test for Volume of Cell Space of Lump Coke were accepted for publication as tentative and appear on pages 763 and 766, respectively.

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[1] See p. 763.—ED.

REPORT OF COMMITTEE D-7
ON
TIMBER

During the past year, Committee D-7 has cooperated with the Central Committee of Lumber Standards which came into being as a result of suggestions by Secretary of Commerce Hoover. The object of the Central Lumber Committee is to standardize, if possible, all grading rules for structural timber and lumber. The representatives of the American Society for Testing Materials have taken an active part in discussions with a view of determining to what extent the present standards of the Society should be revised. Considerable progress has been made and it is anticipated that during the coming year some recommendations will be forthcoming from the Central Committee, upon which our Society can take action.

Of the sub-committees, Sub-Committee VI on Timber Preservatives and Sub-Committee IX on Methods of Testing have prepared separate reports which are appended hereto. Committee D-7 recommends that the revisions of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 18)[1] outlined in the report of Sub-Committee VI be approved, including the acceptance for publication as tentative of the proposed Method of Test for Coke Residue of Creosote Oil.

This report has been submitted to letter ballot of the committee, which consists of 35 members, of whom 20 have voted affirmatively, none negatively, and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Sampling and Analysis of Creosote Oil were accepted for publication as tentative and appear on page 972.

The proposed Tentative Method of Test for Coke Residue of Creosote Oil was accepted for publication as tentative and appears on page 771.

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[1] 1921 Book of A.S.T.M. Standards.

REPORT OF SUB-COMMITTEE VI ON TIMBER PRESERVATIVES

The sub-committee recommends the withdrawal from the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 18)[1] the sub-division designated "Float Test of Residue" comprising Sections 17 and 18. It further recommends that the Tentative Method of Float Test for Bituminous Road Materials (D 139 – 22 T), prepared by Committee D-4 on Road and Paving Materials, with the revisions being recommended by that committee in its report for this year, be approved as a method of testing creosote oil.

The sub-committee further recommends that Sections 19 and 20 of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 18), comprising a description of a coke residue test be withdrawn and that the Proposed Tentative Method of Test for Coke Residue of Creosote Oil, appended hereto,[2] be accepted for publication as tentative to supersede, when adopted as standard, the present method described in Standard Methods D 38 – 18.

In support of the recommended withdrawal of the coke residue test and the submission of a substitute therefor as a tentative standard, the sub-committee offers the following comparative laboratory data:

A sample of creosote oil was prepared in the laboratory of the chairman and portions of this sample were sent to several members of the sub-committee and tested in their respective laboratories. Comparative tests were given in tabulated form, showing the results by the proposed method in comparison with the existing standard method.

	Proposed Method		Old Method	
	Individual Tests	Average	Individual Tests	Average
Laboratory B........	5.3	...	...	...
	5.4	5.4	...	7.8
Laboratory A........	6.2	...	...	...
	6.1	...	...	...
	6.2	6.2	...	7.1
Laboratory U........	5.2	...	6.0	...
	5.3	...	6.1	...
	5.5	...	6.5	...
	5.5	5.4	6.6	6.3

These comparative results substantiated very considerable investigation that had already been made in one of the laboratories, showing better comparative results by the proposed new method than by the old method.[3]

Respectfully submitted on behalf of the sub-committee,

S. R. Church,
Chairman.

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 771.—Ed.

[3] "Coke Residue Test for Creosote Oil" by Reeve and Yeager, *Journal of Industrial and Engineering Chemistry*, Vol. 14, No. 10, p. 966 (1922).

REPORT OF SUB-COMMITTEE IX ON METHODS OF TESTING

While Sub-Committee IX held no meetings during the year, active work in connection with the standardization of wood testing was nevertheless in progress. The outstanding development during the year was the organization of a Sectional Committee, of the American Engineering Standards Committee, on Methods of Testing Wood. At the organization meeting held in Washington on December 13, 1922, Mr. L. J. Markwardt was elected chairman and Mr. M. O. Withey was elected secretary. The Tentative Methods of Testing Small Clear Specimens of Timber (D 143 – 22 T) of the American Society for Testing Materials were presented by Mr. C. L. Warwick for the consideration of the Sectional Committee in its development of American standards. The American Society for Testing Materials is officially represented on the American Engineering Standards Sectional Committee by Mr. M. O. Withey.

A foreign inquiry was received asking for information as to the basis on which the Tentative Methods of Testing Small Clear Specimens were founded, and calling attention to an article entitled "Principles of a Standard Method of Testing Wood," which appeared in the 1906 Proceedings of the International Association for Testing Materials. In view of other similar inquiries, the following history of development of these methods may be pertinent at this time.

The Tentative Methods of Testing Small Clear Specimens of Timber published by the American Society for Testing Materials and now under consideration by the Sectional Committee of the American Engineering Standards Committee are based largely on the U. S. Forest Service procedure, which was developed from an intensive study of both foreign and American experience and methods, together with such later modification as years of experience has shown to be desirable.

Some twenty years or so ago, with the thought of establishing a definite timber testing procedure, a very careful study of German and other literature was made, as well as an analysis of American experience, including the work of Mr. B. E. Fernow, Mr. Filibert Roth, and Mr. J. B. Johnson in the U. S. Bureau of Forestry, and the tests conducted at the Watertown Arsenal. The different methods of test were then subjected to a detailed analysis and Forest Service *Circular No. 38*, "Instructions to Engineers in Timber Tests" was prepared and published in 1906 under the direction of Mr. W. K. Hatt, who was then in charge of all the timber testing work in the U. S. Forest Service. *Circular No. 38* was primarily intended to standardize the technique of U. S. Forest Service timber testing, which was then in active progress at Yale University, Charleston, S. C., the University of California, and Purdue University.

In 1910 these testing stations were consolidated as a unit of the Forest Products Laboratory. With this consolidation developed the opportunity for making a comprehensive study of the properties of various species of woods, and a working plan was accordingly prepared for use in connection with *Circular No. 38* to afford detailed procedure for an exhaustive study of American species. Mr. J. A. Newlin, Mr. T. R. C. Wilson, and Mr. A. L. Heim were primarily responsible for this work, with Mr. W. K. Hatt and Mr. McGarvey Cline acting in consulting capacity. Mr. Newlin who is now in charge of the section of timber mechanics at the Forest Products Laboratory was, in fact, continuously associated and in contact with all this development of procedure and technique, including the preparation of *Circular No. 38*.

The paper on "Principles of a Standard Method of Testing Wood" which was presented by Mr. Rudeloff at the Brussels Congress of the International Association for Testing Materials, 1906, was used in this development, and was, in general, followed except where the procedure conflicted with the experience of the U. S. Forest Service. Thus, for instance, the cleavage test adopted is an adaptation of that suggested in the 1906 Proceedings referred to, while the ball test adopted for hardness was that of Mr. Gabriel Janka of Austria.

However, Mr. Rudeloff's paper was presumably intended only as an outline of principles, and consequently, does not give full details of methods of selecting material and making tests, and does not provide specifically for the standardization of all factors which affect test results.

The Tentative Methods of Testing Small Clear Specimens of Timber, on the other hand, give full details regarding the entire procedure from selection of the trees to the test manipulation, and therein lies the fundamental difference in conception on which the two systems are based. Uniformity of test results necessitates a standardization of size and proportion of test specimens, as well as such other factors as rate of loading, and, consequently, involves the specification of detailed procedure.

Five different mechanical tests were suggested by Mr. Rudeloff, namely,

1. Pressure
2. Bending (static)
3. Shearing
4. Tension
5. Splitting

It was felt that data was needed on other properties than are brought out by the above tests, and accordingly the following additional tests were included in the tentative standard:

Impact Bending
Compression-perpendicular-to-grain
Hardness
Tension-perpendicular-to-grain

It has been previously pointed out that more than a half million tests have already been made on over 150 species of American woods by the U. S. Forest Service under essentially the same methods as specified in the tentative standard. In like manner, the Canadian Forest Products Laboratory has used the same basic procedure for over 10 years, and more recently the methods have been adopted by the Forest Research Institute and College, Dehra Dun, India, the State Forest Service, Wellington, N. Z., and the Forest Department, Pretoria, Union of South Africa.

Plans are now under way for developing a standard procedure for testing structural timbers, or large size timbers containing defects.

Respectfully submitted on behalf of the sub-committee,

L. J. MARKWARDT,
Chairman.

REPORT OF COMMITTEE D-8
ON
WATERPROOFING MATERIALS

Committee D-8 has held three meetings during the past year. Its Sub-Committee on Specifications for Waterproofing Signal Wire Conduits and Electrical Installations has been discharged as upon investigation there was found to be no demand for such specifications. The present organization of the committee includes the following sub-committees:

On Nomenclature and Definitions.
On Service Tests.
On Bituminous Grouts and Mastics.
On Membrane Materials.
On Bituminous Coatings for Cold Application.

Sub-Committee on Service Tests, P. G. Lang, Chairman.—The organization of this sub-committee was finally effected on December 2, 1922. The sub-committee has divided its work into two parts:

1. Obtaining records of actual service performance of various waterproofing compounds which have been and still are in use. This work will consist principally in the compilation of data relating to past and current practice, with a view to identifying those features whose value has been demonstrated by actual service. This phase of the work may be properly divided into two sub-classes, namely,

(*a*) Membrane methods of waterproofing.
(*b*) Other surface methods of waterproofing.

2. Testing samples of various classes and brands of waterproofing materials. It is probable that accelerated tests will serve the purpose of this work.

Sub-Committee on Bituminous Grouts and Mastics, S. R. Church, Chairman.—This sub-committee presents for publication as tentative the following specifications, appended hereto:[1]

For Asphalt Mastic for Use in Waterproofing.
For Bituminous Grout for Use in Waterproofing Above Ground Level.
For Bituminous Grout for Use in Waterproofing Below Ground Level.

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[1] See pp. 781–786.—Ed.

Sub-Committee on Membrane Materials, Herbert Abraham, Chairman.—This sub-committee presents for publication as tentative the following specifications, appended hereto:[1]

For Felted Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

For Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

For Burlap Saturated with Bituminous Substances for Use in Waterproofing.

Sub-Committee on Bituminous Coatings for Cold Application, C. N. Forrest, Chairman.—The following items for use in dampproofing are now receiving the attention of this sub-committee:

1. Stone Backing.
2. Heavy Bodied Bituminous Coating.
3. Fiber Filled Bituminous Coating.
4. Fiber Filled Bituminous Cement.

A proposed specification on each item has been prepared and discussed by both the sub-committee and the main committee.

Analytical data on a large number of such materials offered in trade is now being compiled for the consideration of the sub-committee and it is expected that suitable specifications on each subject can be presented to the committee during the current calendar year.

PROPOSED REVISIONS OF TENTATIVE SPECIFICATIONS AND METHODS OF TEST

1. *Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 - 22 T)*.[2]—The following revisions are recommended in these methods:

Section 1.—Change the definitions to read as follows:

Bituminous Grout.—A mixture of bituminous material as a binder and sandy mineral matter as an aggregate, which at approximately 300° F. becomes sufficiently fluid to flow into place without mechanical manipulation, and which on cooling congeals to a compact mass.

Asphalt Mastic.—(1) A mixture containing asphaltic material as a binder and graded mineral matter as an aggregate, or (2) pulverized natural bituminous rock (to which bitumen may be added); either of which at approximately 400° F. may be poured into place but which requires trowelling to form it into a compact mass.

Asphalt Mastic Cake.—A mixture containing asphaltic material as a binder and an aggregate consisting of calcareous or siliceous dust, together with sand, cast in the form of blocks or "cakes" and adapted for use in preparing asphalt mastic.

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[1] See pp. 787–795.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 884 (1922).

Section 2 (b).—Change the first word from "Bituminous" to "Asphalt." Change the note at the end of Section 2 (*b*) from its present form: namely,

"NOTE.—Where the properties of the extracted bituminous matter are to be determined, it may be necessary in certain cases to take as much as 500 g. for analysis."

to read as follows:

"NOTE.—Where the properties of the extracted bituminous matter are to be determined, 500 g. shall be taken and extracted with pure benzol as described in Sections 4 and 6 and examined as described in Section 7."

Add a new heading and new Section 7 to read as follows, renumbering and re-lettering the subsequent section and heading, accordingly:

"(*C*) Recovery and Examination of Extracted Bitumen.

"7. The benzol solution containing the asphalt shall be evaporated to a thick viscous liquid on a steam or water bath, then transferred to a steam oven at 105° C. (221° F.) until its weight is nearly equal to the percentage of asphalt calculated in accordance with Section 5. It shall then be transferred to a hot plate and heated carefully with stirring at a temperature not exceeding 121° C. (250° F.) until its weight is exactly that determined in accordance with Section 6."

It is recommended that the methods, as revised, be continued as tentative.

2. *Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing (D 146 – 22 T).*[1]—The following changes are recommended:

Section 7.—Change to read as follows by the addition of the italicized words and figures and the omission of the words in brackets:

"Each roll sampled shall be laid flat, the first convolution or two carefully unwound, and with a knife and straight edge the sheet shall be cleanly cut across at right angles to the edges. A section measuring 30 in. in the direction of the roll's length shall be removed. If the material is surfaced with sand or other fine material any detached particles belonging to each 30-in. section should be retained. The width of each section shall be measured to the nearest $\frac{1}{32}$ in. Each section, together with any detached surfacing, shall be weighed to the nearest gram. The weight in pounds per 100 sq. ft. *or the weight in ounces per sq. yd.* shall be calculated from the [formula] *formulas:*

$$\text{[Weight] } \textit{Pounds} \text{ per 100 sq. ft.} = 1.0582 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

$$\textit{Ounces per sq. yd.} = \textit{1.5238} \times \frac{\textit{Weight of 30-in. section in grams}}{\textit{Width of 30-in. section in inches}}$$

"From the results obtained for each roll sampled, the minimum, maximum, and average weight [in pounds per 100 sq. ft.] shall be calculated."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 875 (1922).

Section 10.—Change the last sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The readings for each [rolled sample] *roll sampled* shall be averaged and the minimum, maximum and average thickness calculated to the nearest 0.001 in."

Section 11.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"From each specimen, 2-in. strips shall be cut as shown at A-1 and A-2 in Fig. 1. The 2-in. strips shall be cut into 1-in. squares. About 50 g., selected at random, shall be accurately weighed and distilled with 100 cc. of [water-saturated solvent naphtha (crude xylol)] *a coal-tar distillate of which 5 to 10 per cent boils below 100° C. (212° F.) and of which at least 90 per cent distills up to 180° C. (356° F.)* in an apparatus of the form and under the conditions prescribed in the Tentative Method of Test for Water in Petroleum Products (Serial Designation: D 95 - 21 T) of the American Society for Testing Materials. The flask containing the [xylol] *solvent* and sample shall be heated in a paraffin bath at a temperature of 302 to 338° F. (150 to 170° C.) until no further [distillate] *water* passes over. The distillate shall be allowed to stand in the graduated receiver [or centrifuged] until the water separates, whereupon the volume of water shall be measured and its weight calculated. From this, the average percentage of moisture in the fabric, as received, shall be calculated."

Section 12.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"(*a*) Felted Fabrics.—With a photographic trimmer having a stop attached exactly 1 in. behind the blade, ten strips shall be cut with the fiber grain, as shown at B-1 to B-10 (Fig. 1) and ten strips across the fiber grain as shown at C-1 to C-10. Each strip should measure 6 in. and have parallel sides 1 in. apart (within $\frac{1}{32}$ in.) with the edges cut straight and clean. Both sets of strips shall be tested at [77° F. (25° C.)] *70° F. (21.1° C.)*, using a tension testing machine such as the Scott Strength Tester (Type F, 100 lb. capacity), the Perkins Strip Tester, or equal, in which the clamps are attached to swivels free to move in any direction. The test strips shall be gripped $1\frac{1}{2}$ in. on each end, leaving approximately 3 in. between the clamps. The tension shall be increased at a uniform speed of 3 lb. per second, using a metronome. If any strip breaks nearer than $\frac{1}{2}$ in. to either clamp, the reading shall be disregarded, and an additional strip shall be tested in its place. The ten readings, with and across the grain, respectively, shall be averaged for each roll sampled. From these results the [minimum, maximum and] average strength with and across the fiber grain, respectively, of the fabric as supplied, shall be calculated.

"(*b*) Woven Fabrics.—Woven fabrics shall be tested at [77° F. (25° C.)] *70° F. (21.1° C.)* in accordance with the "grab test *No. 2*" as described in Section 12 (*b*) of the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials, *with the exception that the distance between the jaws shall be 3 in.* [(NOTE.—The percentage elongation before rupture may also be recorded.)]"

Add a note to read as follows:

"NOTE.—As a referee method, or in case any dispute arises regarding the strength, the test shall be repeated, with the exception that the fabric before testing shall be exposed at least two hours in an atmosphere of 65 per cent relative humidity at 70° F. (21.1° C.)."

Section 13.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"With the trimmer described in Section 12 (*a*), five 6-in. strips shall be cut with the fiber grain, as shown at D-1 to D-5 (Fig. 1) and immersed in water at 77° F. (25° C.) for *from 10 to* 15 minutes. These strips shall be bent through 180 deg. at a uniform speed, in exactly 2 seconds, around a [pin] *mandril,* the diameter of which shall be as follows: The first around a [pin] *mandril* 25 mm. in diameter; the second, around a [pin] *mandril* 20 mm. in diameter; the third, around a [pin] *mandril* 15 mm. in diameter; the fourth, around a [pin] *mandril* 10 mm. in diameter, and the fifth, around a [pin] *mandril* 5 mm. in diameter. *The test may also be made at 32° F. (0° C.).* The pliability shall be expressed numerically from 1 to 10 as follows:

(1) Cracks entirely through the sheet on the 25-mm. [pin] *mandril.*
(2) Cracks part way through the sheet on the 25-mm. [pin] *mandril.*
(3) Cracks on the 25-mm. [pin] *mandril.*
(4) Cracks on the 20-mm. [pin] *mandril.*
(5) Cracks on the 15-mm. [pin] *mandril.*
(6) Cracks on the 10-mm. [pin] *mandril.*
(7) Cracks on the 5-mm. [pin] *mandril.*
(8) Cracks when bent through 180 deg. flat on itself.
(9) May be bent through 180 deg. flat on itself in one direction without cracking, but will crack when bent through 360 deg. in the opposite direction.
(10) May be bent through 180 deg. flat on itself in one direction and then through 360 deg. flat on itself in the opposite direction without cracking.

The readings for each roll shall be averaged separately, and from these results the minimum, maximum and average pliability of the felt shall be calculated."

Section 15.—Add a new Section 15 to read as follows, re-numbering the subsequent sections accordingly:

"*Loss on Heating.*—From each specimen, 12 by 6-in. strips shall be cut at *K-1* and *K-2* in Fig. 1, care being taken not to disturb any of the detached surfacing. Each strip shall be weighed and suspended in the center of an air oven maintained at 221° F. (105° C.) ± 5° F. (3° C.) with a thin wire fastened through holes punctured near one edge. The thermometer shall be inserted in the oven to such a depth that its bulb will be in line with the center of the specimens. The strips shall be kept in the oven for exactly 5 hours, then cooled and removed carefully, and each specimen weighed. The average loss shall be calculated as a percentage and the average percentage of moisture (ascertained in Section 11) deducted. The final figure shall represent the average loss on heating, exclusive of moisture."

Add a marginal heading to the present Section 15, reading "Desaturated Fabric" and add a sentence to read as follows:

"Where a coal-tar pitch saturant has been used, the moisture-free weight of the desaturated fabric shall be corrected for the carbonaceous matter retained mechanically in its interstices, by means of the method described in Section 17."

Omit the note appearing at the end of the present Section 15, reading as follows:

"NOTE.—The following colorimetric method for determining foreign matter adhering to the surface of the desaturated felt, such as carbonaceous matter derived from a coal-tar pitch saturant, is published by the committee, without as yet having been conclusively tried out, that the committee might receive comments or criticisms from those interested."

Section 16.—Add a marginal heading reading "Retained Carbonaceous Matter" and a new opening sentence to read as follows:

"The following colorimetric method shall be used to ascertain the carbonaceous matter derived from a coal-tar pitch saturant and retained by the desaturated fabric."

Add a new Paragraph (*d*) to read as follows:

"(*d*) The weight of moisture-free fabric ascertained in Section 16 shall be corrected by deducting the weight of adhering carbonaceous matter."

Section 17.—Change from its present form: namely,

"The weight of bituminous matter in the original fabric represents the difference in weight between the original material and the sum of the weights of the desaturated fabric (corrected for any adhering foreign matter, such as carbonaceous matter) plus moisture (ascertained in Section 11) plus any comminuted surfacing present (ascertained in Section 9 plus the amount recovered from the surface of the desaturated fabric, plus the amount obtained on evaporating and igniting the bituminous extract)."

to read as follows:

"*Total Comminuted Surfacing.*—The total comminuted surfacing plus any filler present in the bituminous saturant represents the sum of the detached comminuted surfacing (Section 9), the amount brushed off from the surface of the desaturated fabric (Section 16), plus the amount recovered upon evaporating and igniting the bituminous extract obtained in accordance with Section 16."

Add a new Section 19 to read as follows, re-numbering the subsequent sections accordingly:

"19. *Bituminous Saturant.*—The weight of bituminous saturant represents the difference between the weight of the original fabric (Section 7), and the sum of the weights of the moisture-free desaturated fabric (Sections 16 and 17), plus moisture (Section 11), plus the total comminuted surfacing and filler present (Section 18)."

Section 18.—Change the center heading from: "(A) Woven Cotton Fabrics" to read "(A) Woven Fabrics" and change the section to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "*Weight.*—Woven [cotton] fabrics shall be tested *for weight and number of threads per in.* in accordance with Sections 6 to 11, inclusive, of the Standard General Methods [for] *of* Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials."

Omit the present side heading, reading: "Woven Cotton Fabrics."

Figure 1.—Change this figure to include two 6 by 12-in. sections (*K–1* and *K–2*), to be inserted along side of the present Sections *A–1* and *A–2*.

It is recommended that the methods, as revised, be continued as tentative.

3. *Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (D 40 – 22 T).*[1]—It is recommended that in Section 4 (*g*) the requirement for insoluble matter reading "not more than 5 per cent" be changed to read "not more than 1 per cent and that the specifications as revised be continued as tentative."

4. *Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level (D 144 – 22 T).*[2]—The following revisions are recommended in these specifications:

Section 1.—Add the following sentence to this section:

> "It may be used below ground level."

Section 4 (a).—Change the maximum softening point now reading "190° F. (87.7° C.)" to read "200° F. (93.3° C.)."

Section 4 (b).—Change the minimum penetration at 25° C. (77° F.) now reading "30" to read "25."

Section 4 (g).—Change the matter insoluble in carbon disulfide, now reading "not more than 5 per cent" to read "not more than 1 per cent."

It is recommended that the specifications, as revised, be continued as tentative.

5. *Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 42 – 22 T)*[3] *and Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 145 – 22 T.)*[4]—The following changes are recommended:

In both specifications change the words "coal-tar pitch" occurring in the title and elsewhere to read "high-carbon coal-tar pitch."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 863 (1922).

[2] *Ibid.*, p. 865.

[3] *Ibid.*, p. 869.

[4] *Ibid.*, p. 871.

In both specifications insert the following footnote:

> "Specifications are now in course of preparation for low-carbon coal-tar pitch for use in damp-proofing and waterproofing below and above ground level, respectively."

It is recommended that the specifications, as revised, be continued as tentative.

NEW SPECIFICATIONS SUBMITTED AS TENTATIVE

The committee recommends for publication as tentative the following specifications appended hereto as prepared by the Sub-Committee on Bituminous Grouts and Mastics and the Sub-Committee on Membrane Materials.

(*a*) Specifications for Asphalt Mastic for Use in Waterproofing.

(*b*) Specifications for Bituminous Grout for Use in Waterproofing Above Ground Level.

(*c*) Specifications for Bituminous Grout for Use in Waterproofing Below Ground Level.

(*d*) Specifications for Felted Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

(*e*) Specifications for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

(*f*) Specifications for Burlap Saturated with Bituminous Substances for Use in Waterproofing.

COMBINATION OF TENTATIVE METHODS OF SAMPLING BITUMINOUS MATERIALS

During the past year, representatives of Committee D-4 on Road and Paving Materials and Committee D-8 were appointed to prepare if possible a combination of the tentative methods of sampling bituminous materials submitted by these committees in 1922 under serial designations D 140 - 22 T and D 148 - 22 T, respectively. Such a combination satisfactory to both committees was effected by adopting the methods which had been recommended by Committee D-4 with a rewording of Section 12 and the insertion of a new Section 13. These changes are given in the report of Committee D-4.

Committee D-8 therefore joins with Committee D-4 in recommending that the Tentative Methods of Sampling Bituminous Materials (D 140-22 T) be amended as indicated and further recommends that the Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums (D 148 - 22 T)[1] be discontinued.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 890 (1922).

The results of the letter ballot of the committee upon the recommendations made in this report are as follows:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF EXISTING TENTATIVE STANDARDS			
Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 - 22 T)	20	1	7
Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing (D 146 - 22 T)	21	0	7
Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (D 40 - 22 T)	22	0	6
Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level (D 144 - 22 T)	21	1	6
Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (D 42 - 22 T)	20	0	8
Tentative Specifications for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level (D 145 - 22 T)	20	0	8
II. PROPOSED NEW TENTATIVE STANDARDS			
Proposed Tentative Specifications for Asphalt Mastic for Use in Waterproofing	21	0	7
Proposed Tentative Specifications for Bituminous Grout for Use in Waterproofing Above Ground Level	22	0	6
Proposed Tentative Specifications for Bituminous Grout for Use in Waterproofing Below Ground Level	22	0	6
Proposed Tentative Specifications for Felted Fabrics Saturated with Bituminous Substances for Use in Waterproofing	18	1	9
Proposed Tentative Specifications for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing	19	0	9
Proposed Tentative Specifications for Burlap Saturated with Bituminous Substances for Use in Waterproofing	18	0	10
III. PROPOSED COMBINATION OF EXISTING TENTATIVE STANDARDS			
Proposed Combination of Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums (D 148 - 22 T) and Tentative Methods of Sampling Bituminous Materials (D 140 - 22 T)	22	0	6

This report has been submitted to letter ballot of the committee, which consists of 28 members, of whom 22 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. T. WAGNER,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level; for Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level; for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level; and for Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level; and of the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures; and of the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing were accepted. The tentative standards as thus revised appear on pages 773–780 and 796–810, respectively.

The proposed Tentative Specifications for Asphalt Mastic for Use in Waterproofing; for Bituminous Grout for Use in Waterproofing Above Ground Level; for Bituminous Grout for Use in Waterproofing Below Ground Level; for Felted Fabrics Saturated with Bituminous Substances for Use in Waterproofing; for Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing; for Burlap Saturated with Bituminous Substances for Use in Waterproofing, referred to in this report, were accepted for publication as tentative and appear on pages 781–795.

The withdrawal, recommended in this report, of the Tentative Method of Sampling Bituminous Materials Shipped in Barrels or Drums was approved.

REPORT OF COMMITTEE D-9

ON

ELECTRICAL INSULATING MATERIALS

The committee has held three meetings during the year in addition to the one to be held at this annual meeting of the Society. They were held in New York City on November 10, 1922, February 5 and 6, 1923, and March 19 and 20, 1923.

The committee has continued the policy, which has been followed since its organization, of confining its activities to the development and standardization of tests and test procedures for electrical insulating materials. The state of the art does not yet appear to warrant the committee's undertaking the preparation of material specifications although it seems probable that this can be done in the very near future in the case of one or two materials. The work of the committee has been carried on along the same lines as during the past two years, that is, through sub-committees dealing with various general classes of materials, although naturally there is considerable overlapping because the same test procedures are in many cases applicable to more than one class of material. Revisions of certain of the existing tentative standards have been agreed upon, two proposed tentative standards have been prepared and a considerable amount of work has been done on the program outlined in the last year's report, but this is not yet in shape to place before the Society.

EXISTING TENTATIVE STANDARDS

Five tentative standards prepared by this committee are now before the Society. The following action in respect to them is recommended:

Tentative Methods of Testing Insulating Varnishes (*D 115 - 22 T*).[1]—Certain changes in these methods were made at the last annual meeting. Additional experience and study has shown that they could be further improved and it is recommended that the following revisions be made:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 22, Part I, p. 892 (1922)

Section 3 (*a*).—Change the first sentence from its present form: namely,

"The viscosity shall be determined with a MacMichael, Stormer plastometer or other suitable type of instrument."

to read as follows:

"The viscosity shall be determined with a Stormer or MacMichael viscosimeter and shall be stated in terms of the viscosity of distilled water determined with the same instrument under the same conditions."

Section 5 (*b*).—Change from its present form: namely,

"The specimens shall be dipped once in the varnish and withdrawn slowly and uniformly (about 15 in. (38 cm.) per min.). The consistency of the varnish shall be first so adjusted by trial that the thickness of the film of varnish on each side of the metal shall be between 0.022 mm. (0.0009 in.) and 0.026 mm. (0.001 in.)."

to read as follows:

"The specimen shall be dipped once in the varnish at a room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The consistency of the varnish shall be first so adjusted by trial that, when dry as determined in accordance with Section 7, the thickness of the film of varnish on each side of the metal shall be between 0.022 mm. (0.0009 in.), and 0.026 mm. (0.001 in.). Care shall be taken before dipping the specimens that the varnish has stood in the dipping tank for a sufficient length of time to be free from air bubbles."

Section 6 (*b*).—Add a sentence to read as follows:

"In the case of slow-drying varnishes, this 10-minute period may be lengthened at the discretion of the operator.

Section 8 (*b*).—Change to read as follows by the addition of the italicized word and the omission of the words in brackets:

"Each specimen shall be dipped [four times] *twice*, as specified in section 5 (b), once in each direction, in order to give a more uniform thickness of coating."

Section 8 (*c*).—Change from its present form: namely,

"Specimens of air-drying varnish shall be dried in free air at a room temperature of approximately 20° C. (68° F.) for a period 25 per cent longer than that found in Section 7."

to read as follows:

"Specimens of air-drying varnish shall be dried in free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period 600 per cent longer than that determined in accordance with Section 7, provided such period does not exceed 24 hours."

Section 8 (*d*).—Change from its present form: namely,

"Specimens of baking varnish shall be drained and then baked for a period 25 per cent greater than that found in Section 7."

to read as follows:

"Specimens of baking varnish shall be drained and then baked after each dip for a period 300 per cent greater than that determined in accordance with Section 7 provided such period does not exceed 24 hours."

Section 9 (a).—Add a note at the end of this section to read as follows:

"NOTE.—When necessary, in order to get ten punctures, an additional specimen should be tested."

Section 14 (b).—This section now prescribes making a bending test with rods of three different diameters. It is recommended that one rod only: namely, the $\frac{1}{8}$-in. diameter rod, be used and that the criterion be the number of hours at which cracking occurs with this one rod and that therefore this section be changed to read as follows:

"Each specimen shall be bent through 180 deg. over a rod 0.32 cm. ($\frac{1}{8}$ in.) in diameter. The number of hours of baking at which first cracking in the insulation occurs shall be noted and reported."

Section 19.—Add a note to read as follows:

"NOTE.—Incipient disintegration of the surface of the varnish may sometimes be detected by examining the oil for turbidity. If a specimen of the oil filtered through filter paper can be distinguished from an unfiltered sample when the two samples are held in front of a strong light, the oil is turbid."

Add seven new sections to read as follows, covering a draining test, an evaporation test, and a test for non-volatile matter to be included in the tentative methods:

DRAINING TEST

(ALSO KNOWN AS "WORKING VISCOSITY" TEST)

20. *Test Specimen.*—A strip of bond paper 0.064 mm. (2.5 mils) in thickness, 10.2 cm. (4 in.) in width and 50.8 cm. (20 in.) in length, shall be immersed in the varnish at a room temperature of approximately 20° C. (68° F.), up to a line previously drawn across the paper a few inches from the top. The paper shall be withdrawn at a slow and uniform rate, care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried or baked (according to the type of the varnish) until dry as determined in accordance with Section 7.

21. *Measurements.*—The thickness of the specimen in mils shall be measured at points 5.1 cm. (2 in.), 17.8 cm. (7 in.) and 30.5 cm. (12 in.), respectively, from the line to which the specimen was immersed.

22. *Report.*—The thickness of each film in mils at the three points specified in Section 21 shall be recorded. The difference between the thickness at the upper point (5.1 cm.) and that at the lower point (30.5 cm.) shall be taken as a measure of the variation in the film thickness caused by draining.

EVAPORATION TEST

23. *Procedure.*—One hundred cubic centimeters of the varnish shall be placed in a flat-bottom crystallizing dish approximately 75 mm. (2.95 in.) in

diameter and 45 mm. (1.77 in.) in height. It shall be heated to a temperature of 100° F. (37.8° C.) ± 2° F. (1.1° C.) for a period of 7 hours, the sample being exposed to still air in the open room.

24. *Evaporation.*—The decrease in volume of the sample shall be taken as the evaporation, this decrease being determined by noting the amount of water or kerosene that must be added to fill the dish to the original level.

NOTE.—This test is relative only. That is, it is only suitable for comparing one varnish with another when the tests are made simultaneously under exactly the same conditions.

TEST FOR NON-VOLATILE MATTER

25. *Procedure.*—A portion of the sample shall be placed in a stoppered bottle or weighing pipette and weighed. About 1.5 g. of the sample shall be transferred to a weighed flat-bottom metal dish about 8 cm. (3.15 in.) in diameter, such as the cover of a friction-top tin can. The container shall again be weighed and the exact weight of the portion of the sample transferred to the weighed dish calculated by difference. The dish with its contents shall be heated for three hours in an oven maintained at 105 to 110° C. It shall then be weighed after cooling.

26. *Non-Volatile Matter.*—The ratio of the weight of the residue to that of the original sample expressed as a percentage shall be taken as the percentage of non-volatile matter in the varnish.

The committee recommends that these tentative methods, as revised, be continued as tentative.

Tentative Methods of Testing Electrical Porcelain (*D 116 - 21 T*).—While this tentative standard has been approved by the American Ceramic Society and no changes are desired by the committee at this time, it is recommended that the standard be continued as tentative for another year.

Tentative Methods of Testing Transformer and Switch Oils (*D 117 - 21 T*).—These methods, it is believed, have met with general approval and the committee has no changes to suggest. But in view of the situation in regard to a method of test for durability (sludging) referred to elsewhere in this report, it is recommended that these methods be continued as tentative.

Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials (*D 149 - 22 T*).—A method of testing for dielectric strength of varnished cambric and similar sheet materials when cut into tape having been agreed upon, the committee recommends that Method D 149 be expanded to include requirements for tape by making the following revisions:

Title.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"Tentative Method of Test for [Momentary] Dielectric Strength of Sheet *and Tape* Insulating Materials *Under Momentary Dielectric Stress.*"

Section 1.—Change to read as follows by the addition of the italicized words:

"This test is intended to determine the dielectric strength of sheet *and tape* materials for electrical insulation, under voltage stresses of short duration. It should not be considered as indicating the permanent dielectric strength of the material, as breakdown will take place at a lower voltage when applied for a greater length of time. *It should also be noted that the results with the two procedures specified for sheet material and tape material, respectively, are not comparable because the apparent dielectric strength of thin materials varies with the area of the electrodes.*"

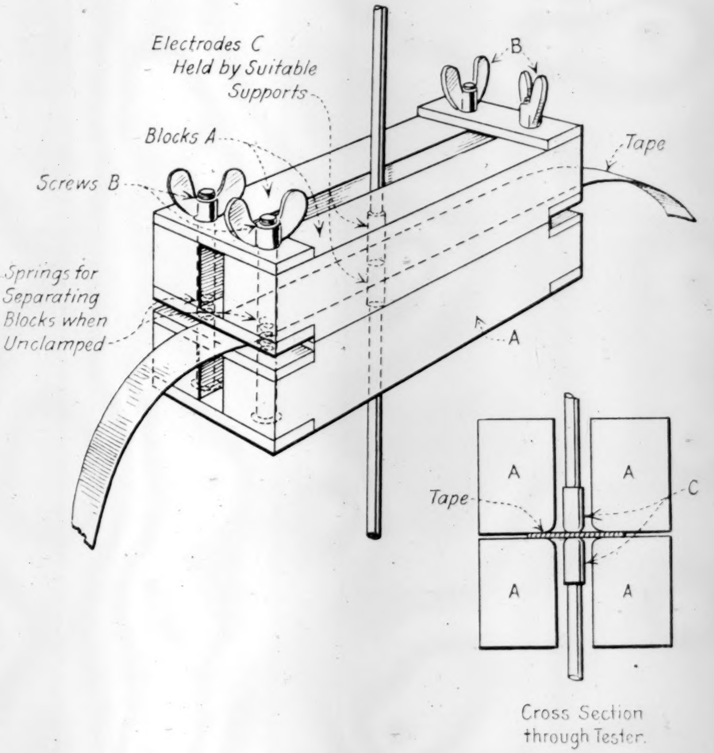
Electrodes C
Held by Suitable
Supports
B
Blocks A
Tape
Screws B
Springs for
Separating
Blocks when
Unclamped
A
A
A
Tape
C
A
A
Cross Section
through Tester.

FIG. 1.—Elementary Form of Tape Tester.

Section 3.—Change from its present form: namely,

"The electrodes shall be of brass or copper and 1 in. (25.4 mm.) thick and 2 in. (50.8 mm.) in diameter. The edges shall be rounded to a radius of ¼ in. (6.35 mm.). The contact surfaces shall be flat and polished."

to read as follows:

"The electrodes shall be of brass or copper with flat polished contact surfaces. For sheet material they shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of ¼ in.

(6.35 mm.). For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.)."

Section 8.—Insert a new Section 8 to read as follows, re-numbering the subsequent sections accordingly:

"The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

"NOTE.—In the appendix are shown two different devices which have been found satisfactory for these tests."

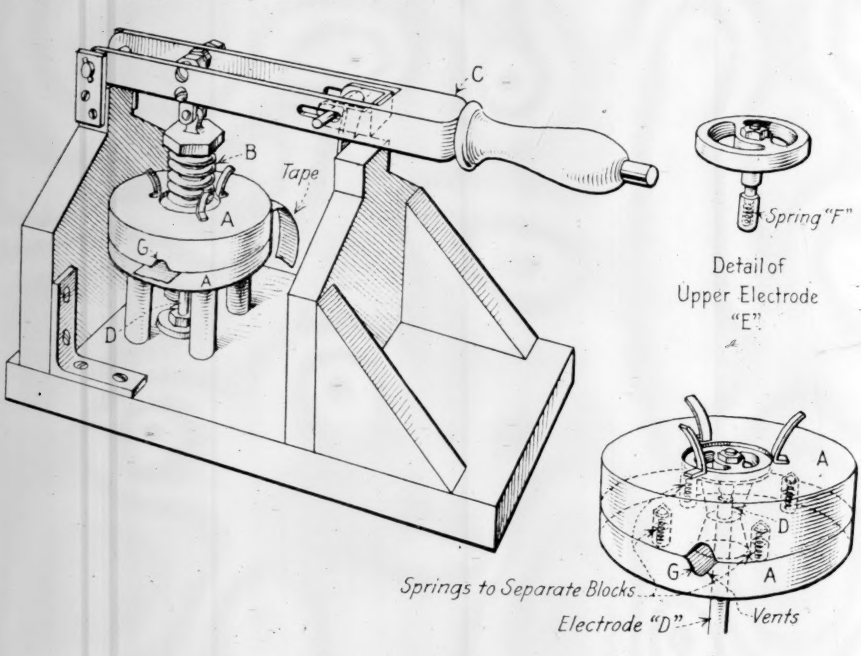

FIG. 2.—Lever-Operated Form of Tape Tester.

Add the following paragraphs as an appendix to the method:

"Referring to Fig. 1, the four wooden clamping blocks, *A*, are held together by the screws *B*. These blocks are impregnated with paraffin which assists in sealing the joints between the wooden blocks and the tape. The electrodes are introduced into the space between the blocks at *C*. The tape can be advanced through the blocks, for each shot, by opening and closing the clamping screws. In order to secure satisfactory results, the blocks must have accurately finished surfaces and should be carefully aligned.

"Referring to Fig. 2, the two impregnated wooden clamping blocks, *A*, are pressed together by the spring, *B*, which is secured to the latched handle, *C*. Releasing the latch allows the blocks, *A*, to be separated to insert the tape or examine the electrodes or contact surfaces of the blocks.

> "The lower electrode, *D*, is fixed in position with its top flush with the lower block *A*. The upper electrode, *E*, is removable and its contact face is pressed against the tape by the internal spring, *F*. The spring *B* seats on the electrode *E*, which rests on a shoulder in the block *A*.
>
> "The openings, *G*, provide the necessary vents for the arc which occurs when the tape under test fails. The successful operation of this device depends upon the accuracy of the contact faces of the blocks *A*, their alignment, the impregnation of the blocks *A* and the vent openings *G*."

The committee recommends that the method of test, as revised, be continued as tentative.

Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies (D 150 – 22 T).—The committee recommends that this method be broadened to cover sheet materials and compounds as well as molded materials by making the following revisions:

Title.—Omit the word "Molded" from the title.

Section 1.—Change the first sentence from its present form: namely,

> "This method of test is intended to apply to non-vitreous solid electrical insulating materials that are formed in molds by the application of pressure, either with or without heat."

to read as follows:

> "This method of test is intended to apply to all solid electrical insulating materials."

Section 3.—Change the third paragraph to read as follows, by the addition of the italicized word and the omission of the word in brackets:

> "A condenser employing the test specimen as the dielectric and two [mercury] *metallic* surfaces as the conducting plate."

Section 5.—Change from its present form: namely,

> "The test specimen shall be a disk having the dimensions shown in Fig. 13 of the Appendix. A raised rim about the circumference is provided to hold a layer of mercury to form the upper plate when the specimen is used as a condenser."

to read as follows:

> "(*a*) For testing molded materials, the test specimen shall be a disk having the dimensions shown in Fig. 13 of the Appendix. A raised rim about the circumference is provided to hold a layer of mercury to form the upper plate when the specimen is used as a condenser.
>
> "(*b*) For testing laminated stiff sheet materials, either circular or rectangular test specimens may be used and the specimen shall be of such dimensions that, after fixing the upper mercury surface diameter (or length and

width) at 2 cm. less than that of the specimen, the electrical capacity shall be not less than 100 micro-microfarads (100 $\mu\mu$f.). Specimens 25.4 by 30.4 cm. (10 by 12 in.) are recommended for general use.

"(*c*) For testing solid waxes the test specimen may be cast to the shape mentioned in either Paragraph (*a*) or Paragraph (*b*).

"(*d*) For testing very thin or flexible sheet material, such as varnished paper or mica, tin-foil may be used as the conducting condenser plates. The instructions for capacity and relative areas of conducting plates given in Paragraph (*b*) apply here. Where necessary, a mixture of beeswax and petrolatum may be employed as an adhesive for the tin-foil.

"(*e*) For testing films of insulating varnishes, lacquers, paints, etc., the test specimen shall be as specified for dielectric strength tests in Sections 8 (*a*), (*b*), (*c*), and (*d*) of the Tentative Methods of Testing Insulating Varnishes (Serial Designation: D 115 - 22 T) of the American Society for Testing Materials,[1] except that the consistency of the varnish need not be adjusted. The copper or brass plate shall be one condenser plate and tin-foil the other. The tin-foil sheet shall not be larger than 18 cm. (7.09 in.) square. Both varnish films may be tested individually."

Section 6 (*b*).—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"*When practicable*, the phase difference (power factor) of two specimens shall be measured by the same method and at radio frequencies within the same limits as mentioned in Paragraph (*a*) after the specimens have been immersed in water at a temperature about 20° C. (68° F.) for 48 hours. The [circumference] *edges* of the specimen shall have been protected from the action of the water by dipping it in melted paraffin to a depth of 10 mm. (0.394 in.) [and rotating it]. After removing the specimen from the water, the surface water shall be wiped off with a clean, absorbent cloth, being careful not to handle the paraffined edge, and then allowed to stand in the room away from drafts, and direct sunlight for five minutes before [floating on the mercury surface preparatory to] making the measurements."

Section 7.—Change the second sentence from its present form: namely,

"Sufficient mercury shall be poured on the top of the specimen to cover the upper surface."

to read as follows:

"Sufficient mercury shall be poured on the upper surface of the specimen to cover that surface within the confines of the barrier. In the case of molded materials, the confining barrier shall be of the material of the specimen; in the case of stiff sheet materials, the confining barrier shall be a two-piece copper rectangle or ring made of 0.32-cm. ($\frac{1}{8}$-in.) square copper wire."

Section 12.—In the explanation of "*T*" as used in both formulas, change the word "specimen" to "dielectric," and in the explanation of "*S*," change the word "mercury" to "metallic."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. 22, Part I, p. 892 (1922).

Section 13 (a).—Change to read as follows by the addition of the italicized words:

> "(*a*) The description of the material: *i. e.*, filler *or base*, binder, grade, color and average thickness."

Section 13 (c).—Change the first sentence to read as follows by the addition of the italicized words:

> "A curve for each specimen, showing phase difference (power factor) and dielectric constant plotted as ordinate values, and wave frequencies (wave lengths) as abscissa values for the specimen as received and *when practicable* after immersion in water for 48 hours."

Appendix.—In the second sentence of the introduction, insert the words "or tin-foil" after the word "mercury."

Change the sentence commencing on the twelfth line of page 908 of the 1922 Proceedings, Vol. 22, Part I (1922), from its present form: namely,

> "The condenser C_x is made by floating the molded test specimen on mercury and pouring mercury on the upper surface until it is filled to the molded flange."

to read as follows:

> "The condenser C_x is made by either floating the test specimen on mercury and pouring mercury on the upper surface until it is filled to the confining barriers or by the use of two sheets of tin-foil."

The committee recommends that the tentative methods, as revised, be continued as tentative.

PROPOSED NEW TENTATIVE STANDARDS

Two new methods of test have been prepared and are appended to this report[1] under the following titles:

(*a*) Proposed Tentative Method of Test of Electrical Insulating Materials for Voltage Effects at Radio Frequencies.

(*b*) Proposed Methods of Testing Cable Splicing and Pothead Compounds.

It is recommended that these be published as tentative standards.

MISCELLANEOUS

Insulating Varnishes.—In addition to recommending certain additional methods of test for inclusion with those now in the existing tentative standard for insulating varnishes, the committee has given considerable attention to the problem of determining the proportions of base material and solvent in varnishes.

This class of material is marketed by volume, that is, by the gallon. A purchaser is principally interested in the amount of base or non-volatile matter, since that is the portion that is of permanent value as an insulator—the solvent being simply a conveyor which is ultimately evaporated. In the comparison of varnishes which are sold by the gallon, the amount of solid matter is therefore an important element.

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[1] See pp. 841–851.—ED.

The best method of determining the proportions of solid matter and solvent would appear to be a distillation test and the tentative method of test of the Society for Distillation of Gasoline, Naphtha, Kerosene and Similar Petroleum Products (D 86 – 21 T) has been investigated by the committee to determine its applicability to varnishes. Several laboratories made tests on samples of the same four lots of varnishes in exact accordance with this procedure.

The results were found to be not sufficiently consistent for a standard method. The principal cause of the variation appears to be the lack of a sufficiently sharp end point. A slight modification in the procedure is being investigated which may result in overcoming this difficulty, namely, by locating the thermometer where it will read the temperature of the liquid instead of that of the vapor and also noting the point at which the first drop of discolored solvent is observed.

It was finally agreed to recommend the non-volatile matter test used in many of the Government paint specifications which was found to give very consistent results.[1] This test is a relative one only and furthermore the results are on a weight basis, whereas determinations of the base material and solvent should preferably be on a volume basis.

Molded Materials.—The committee indicated in its report of last year the need of a suitable impact test for materials of this class. It had hoped that the symposium on this general subject held at the last annual meeting of the Society would indicate the preferable line along which the committee should proceed in standardizing such a test, but in this the committee was disappointed. It would obviously be desirable to standardize on a machine already well established in the metallurgical field if it is suitable or could be readily made suitable for molded insulating materials. A few tests have been made with some of the standard types of impact testing machines and while the results are not conclusive, it appears that possibly one of the standard types can be used if it can be obtained in a smaller capacity than the standard sizes now marketed. The study of this matter of impact testing is being continued.

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[1] See recommendations for revision of the Tentative Methods of Testing Insulating Varnishes (D 115 – 22 T), Sections 25 and 26.

No progress can yet be reported on a material specification for this class of insulation which the report of last year suggested might be possible at this time.

Sheet Materials.—The committee has followed the program laid out for this class of materials in the last annual report which listed fifteen tests to be covered. Considerable attention has been given to a method for determining the thermal conductivity of sheet insulating materials which is being extensively used by one of the committee members. It had been expected that the committee would be in position to recommend a method for this test at this time, but certain questions of accuracy arose which required further investigation. Two of the other tests, namely, for dielectric constant and power factor, are referred to elsewhere in this report. The dielectric endurance test method mentioned in the last annual report is still under trial and the committee is not yet ready to make any recommendation. A method of dielectric strength test for tapes was agreed upon and it is recommended elsewhere for inclusion in the existing tentative methods of testing sheet insulating materials.

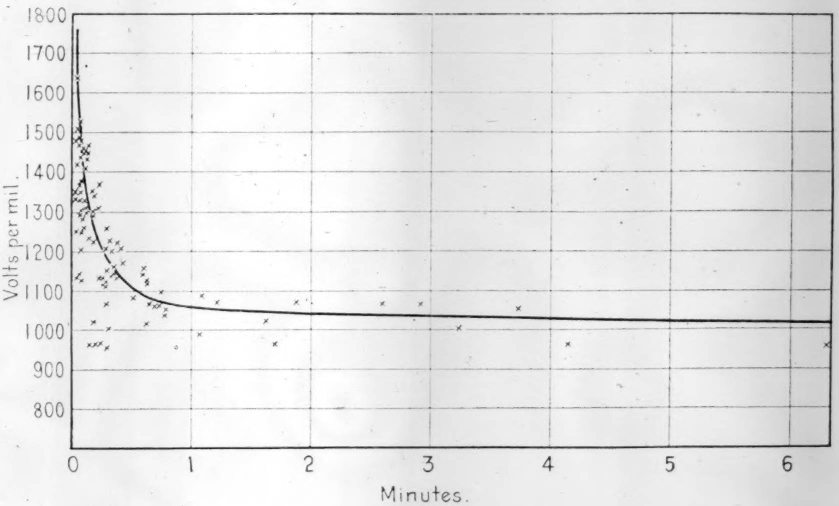

FIG. 3.—Curve Showing Effect of Speed of Raising Voltage on Dielectric Strength of Black Varnished Cambric.

Tests made with A.S.T.M. 2-in. flat electrodes, with edge rounded to a radius of $\frac{1}{4}$ in.

Steps have been taken to standardize methods of testing materials in plate form, as distinguished from flexible sheets, particular attention to be given first to mechanical tests. Some definite standards for such tests will doubtless be offered next year.

The preliminary methods of test for untreated paper referred to in the report of last year have been worked upon further, but the committee has concluded to withhold them until next year in order to get the benefit of the revisions which the Technical Association of the Paper and Pulp Industry is now making of their standard methods of testing paper.

Mr. C. L. Kasson, a member of Committee D-9, has made an investigation[1] of the rate of application of the potential on the test result when making tests of sheet insulating materials for dielectric strength in accordance with the procedure laid down in Tentative Method D 149 - 22 T. The results of two series of such tests are shown in Figs. 3 and 4, each point representing the dielectric strength of black varnished cambric about 12 mils thick obtained in a single test with standard A.S.T.M. electrodes and $\frac{7}{32}$-in. electrodes, respectively. It will be seen that the apparent dielectric strength changes very rapidly for small variations in the rate of application of the

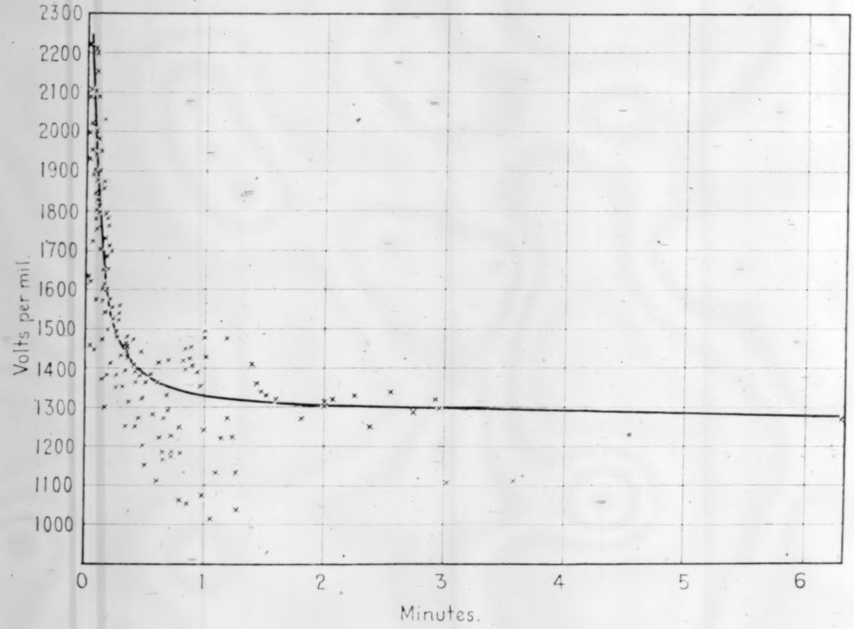

FIG. 4.—Curve Showing Effect of Speed of Raising Voltage on Dielectric Strength of Black Varnished Cambric.

Tests made with an experimental tape tester using $\frac{7}{32}$-in. flat electrodes rounded to a radius of $\frac{1}{32}$-in. The tape was held under a pressure of approximately 100 lb. per sq. in. between two wooden blocks having holes for insertion of the electrodes.

potential. If, for example, the potential is applied at such a rate that puncture occurs in two seconds, the apparent dielectric strength is 30 to 40 per cent greater when the rate of application is such that puncture occurs in 20 seconds. It would seem that according to this evidence, the rate of application of voltage now prescribed in our tentative method is on the steep portion, that is, the unstable part of the curve. In other words, according to this investigation the rate specified in Section 9 (*a*) of Method D 149 – 22 T, namely, "such that puncture occurs in 10 to 15 seconds" is too rapid and the time should be changed to one minute. This matter will be investigated further but it is of interest to note that one minute is being considered for standardization by the British Electrical and Allied Industries Research Association in a proposed standard method of testing which they are considering.

Transformer Oil.—As stated in the last annual report of Committee D-9, the Sub-Committee on Liquid Insulations has given a great deal of attention to the so-called sludging test. As pointed out last year, the apparent inconsistency between different laboratories when using any one of the several methods of testing oil for durability was thought to be largely a matter of differences in small details of procedure which were not sufficiently covered in the original directions. The first work of the sub-committee was to agree on the exact details and this in itself proved to be quite an undertaking. When final agreement was reached on these procedures, samples of four different oils were sent to each of four laboratories for as many of the following tests as it was prepared to carry out in accordance with the agreed procedure:

1. Modified Michie test;
2. Tar test (German No. 9 procedure);
3. Iodine or bromine determination;
4. Deposit test (formalite test).

The results of this investigation, which are summarized in Table I, were very disappointing. While none of the laboratories made all of the tests and we have, therefore, much more data for the Michie procedure than for the others, it is evident that, despite the careful standardization of the details of procedure, very large relative differences between different laboratories were obtained in all of the methods. In the case of the deposit test, a slight modification in the procedure was found desirable and this might have improved the consistency. It may also be that the temperature used in the Michie test, namely, 150° C., is so close to the critical point that

TABLE I.—RESULTS OF SLUDGING TESTS

Laboratory	Modified Michie Test			Tar Test, number	Iodine Addition	Bromine Substitution	Deposit Test, g.
	Sludge, per cent	Gum, per cent	Total, per cent				
			SAMPLE A				
No. 1	0.026	0.002	0.028	1.80	....	1.84	....
	0.016	0.002	0.018	....	....	....	....
No. 2	0.125	Trace	0.125	....	....	....	....
	0.089	Trace	0.089	....	....	....	....
No. 3	0.015	0.035	0.050	....	....	....	....
	0.020	0.259	0.279	....	....	....	....
No 4	....	....	0.014	....	1.80	4.85	0.017
	....	....	0.017	....	1.66	4.82	0.049
	....	....	....	....	1.82	4.60	0.045
No. 5	0.00	0.00	....	....	....	....	....
			SAMPLE B				
No. 1	1.65	0.044	1.694	0.13	0.85	10.7	0.73
	....	....	....	....	....	....	0.77
No. 2	2.017	0.00	2.017	....	−0.31	12.88	2.35
	2.051	0.00	2.051	....	....	....	2.15
	2.39	0.00	2.39	0.20	....	....	....
	2.08	0.00	2.08	0.20	....	....	....
No. 3	0.931	0.046	0.977	....	....	....	....
	1.788	0.033	1.821	....	....	....	....
	0.563	0.024	0.587	....	....	....	....
	1.055	0.028	1.083	....	....	....	....
	1.145	0.030	1.175	....	....	....	....
	1.554	0.028	1.582	....	....	....	....
No. 4	....	....	0.487	....	3.80	11.46	0.71
	....	....	0.524	....	3.65	11.00	0.68
	....	....	....	....	3.86	10.84	0.66
No. 5	1.87	0.05	1.92	....	....	....	....
	1.82	0.04	1.86	....	....	....	....
	1.78	0.06	1.84	....	....	....	....
			SAMPLE C				
No. 1	1.54	0.025	1.565	0.15	0.57	11.9	0.77
	1.45	0.03	1.48	....	....	....	0.82
No. 2	1.452	0.00	1.452	....	−1.10	14.37	3.29
	1.477	0.00	1.477	....	....	....	3.56
	1.94	0.00	1.94	0.10	....	....	....
	1.61	0.00	1.61	0.10	....	....	....
No. 3	1.180	0.30	1.210	....	....	....	....
	1.348	0.017	1.365	....	....	....	....
	1.502	0.026	1.528	....	....	....	....
No. 4	....	....	0.286	....	0.84	12.38	1.27
	....	....	0.400	....	0.70	13.25	1.0
	....	....	....	....	0.71	13.94	1.14
No. 5	1.36	0.02	1.38	....	....	....	....
	1.35	0.02	1.37	....	....	....	....
	1.16	0.02	1.18	....	....	....	....

NOTE.—All of the laboratories did not make all of the tests on all of the samples.

TABLE I.—RESULTS OF SLUDGING TESTS—*Continued*

Laboratory	Modified Michie Test			Tar Test, number	Iodine Addition	Bromine Substitution	Deposit Test, g.
	Sludge, per cent	Gum, per cent	Total, per cent				
			SAMPLE D				
No. 1	0.228	0.007	0.235	2.13	0.13	4.1	0.11
	....	....	....	....	....	....	0.12
No. 2	0.480	....	0.480	....	−0.64	5.62	0.157
	0.425	....	0.425	....	....	....	0.139
	0.765	....	0.765	....	....	....	....
	0.65	....	0.65	3.52	....	....	....
	0.84	....	0.84	3.44	....	....	....
No. 3	....	....	....	....	....	....	....
No. 4	....	....	....	....	Negative	4.85	0.35
	....	....	....	....	Negative	4.62	0.23
	....	....	....	....	Negative	4.90	0.11
No. 5	0.24	0.005	0.245	....	....	....	....
	0.27	0.005	0.275	....	....	....	....
	0.25	0.005	0.255	....	....	....	....
No. 6	0.147	....	0.147	3.25	....	....	....
	0.254	....	0.254	....	....	....	....

NOTE.—All of the laboratories did not make all of the tests on all of the samples.

the oil is unstable and that variations in the test results should be expected.

However, the committee feels that it is questionable if any chemical method can be satisfactory for accurately determining the relative sludging properties of present-day transformer oils in which the amount of sludge formed is relatively low. In other words, chemical methods might be satisfactory for comparing oils which produce a relatively large amount of sludge though they might not be satisfactory where the amount of sludge is small. Furthermore, the question may be fairly asked whether the time at which sludging begins is not a better measure of the durability of the oil than the amount of sludge at the end of a given period.

The committee concludes that of the four chemical methods considered, the modified Michie test and the deposit (formalite) test give the more directive results and offer the best means of judging oils when carried out by experienced and expert experimenters. The deposit test is a relatively short test which gives results quickly.

As the procedures for these tests together with that for the tar number as finally used in this investigation may be of service to the members, they are given in Appendix II.

The committee is studying a simple method which is being submitted by a member of the committee, E. A. Snyder of the Pittsfield Works of the General Electric Co., and which is described in Appendix I. In it the time elapsed at which the first sign of formation of sludge is noted is taken as a measure of the sludging tendency of the oil. The method consists essentially in exposing a sample of the oil in an oven at 120° C. through which air is passed at a slow rate. A specimen of the oil is examined at daily intervals for sludge by centrifuging 15 cc. in a small tapered tube. Preliminary results indicate that the method promises to be considerably more sensitive, reliable, and accurate than any of the chemical methods.

Dielectric Losses, Power Factor and Dielectric Constant.—It is now recognized that among the important characteristics of insulating materials used in the construction of electrical equipment are the power loss in the material, the power factor of the current flowing through the material when it is subjected to electrical stress, and the dielectric constant. The variation of these quantities with temperature is particularly important. The increasing appreciation of these characteristics of insulating materials has led to considerable developmental work in adapting what were formerly looked upon as laboratory research methods to routine and industrial commercial purposes.

The committee has considered recommending a tentative method of test for these quantities but believes it inadvisable to do so, at least at the present time, because there are several methods available which will give accurate results. However, the attention of the committee has been called to a method which, while of a well established type has certain advantages of simplicity and convenience which appear to make it particularly suitable for commercial testing work where the highest precision is not required and where it is applicable to a wide range of materials and a wide range of temperatures. A description of this method is given in Appendix III.

The following is the result of the letter ballot vote of the committee which consists of 36 members on the recommendations contained in this report:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Methods of Testing Insulating Varnishes (D 115 – 22 T)	19	0	17
Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials (D 149 – 22 T)	19	0	17
Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies (D 150 – 22 T)	16	0	20
II. PROPOSED NEW TENTATIVE STANDARDS			
Proposed Tentative Method of Test of Electrical Insulating Materials for Voltage Effects at Radio Frequencies	15	0	21
Proposed Tentative Methods of Testing Cable Splicing and Pothead Compounds	18	0	18

This report has been submitted to letter ballot of the committee, which consists of 36 members, of whom 22 have voted affirmatively, none negatively, and 14 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. FARMER,
Chairman.

H. S. VASSAR,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Methods of Testing Insulating Varnishes; of the Tentative Method of Test for Momentary Dielectric Strength of Sheet Insulating Materials; and of the Tentative Method of Test for Phase Difference (Power Factor) and Dielectric Constant of Molded Electrical Insulating Materials at Radio Frequencies were accepted. The methods as revised appear on pages 811–840.

The proposed Tentative Method of Test of Electrical Insulating Materials for Voltage Effects at Radio Frequencies and the proposed Tentative Methods of Testing Cable Splicing and Pothead Compounds were accepted for publication as tentative and appear on pages 841–851.

APPENDIX I

METHOD FOR DETERMINING SLUDGING PROPERTIES OF TRANSFORMER OILS

By E. A. Snyder

Description of Apparatus

The apparatus for the determination of sludging properties of transformer oils consists essentially of an oven in which the samples are exposed to air at 120° C., the samples being placed on a rotating platform so that all samples are uniformly heated.

Referring to Fig. 1, *A* is a double-walled, circular oven, the space between the walls being filled with asbestos. The outside of the oven is insulated with $\frac{1}{2}$-in. gray felt. The dimensions of the oven are approximately 20 in. in outside diameter by 12 in. deep. *B* is a removable lid having a small hole, *X*, in the top for inserting a pipette to withdraw samples of oil. The lid also has a mica covered peep hole, *Y*, to determine when the different beakers during the course of rotation in the oven are properly located under the sample hole for withdrawing samples. *C* is a $\frac{1}{2}$-h.-p. repulsion induction motor attached with a belt drive to two worm gears which connect by means of a shaft through the bottom of the oven to a rotating table inside the oven. *E* is a thermostat, the bulb of which is located approximately in the center of the oven. This thermostat, by means of the relay, *F*, serves to turn on and off one of two electrical heating units located in a false bottom in the oven. The amount of current flowing in this heating unit may be set at any suitable figure by means of the rheostat, *G*. A second rheostat, *H*, controls the current in the main heater which is always flowing when the oven is in operation. *I* is a recording thermometer whose bulb is in the center of the oven. *T* is a low-form gas washing bottle, having a capacity of 250 cc., which is filled three-fourths full with a good grade of transformer oil and serves as a tell-tale bottle to determine the rate of admission of air through the inlet tube, *S*. Air is passed through the oven at a rate of approximately one cubic foot per hour, which is about equivalent to three bubbles per second when the internal diameter of the glass tube leading through the gas washing bottle is $\frac{1}{4}$ in. The revolving table inside of the oven is fitted with eight seats, each one of which holds a 600-cc. pyrex beaker, Griffin form, approximately $3\frac{1}{4}$ in. in inside diameter and $4\frac{3}{4}$ in. high.

METHOD OF OPERATION

To start a test, the heating units and motor are turned on and the oven is allowed to attain a temperature of 120° C. While the apparatus is coming up to temperature the samples may be prepared as follows:

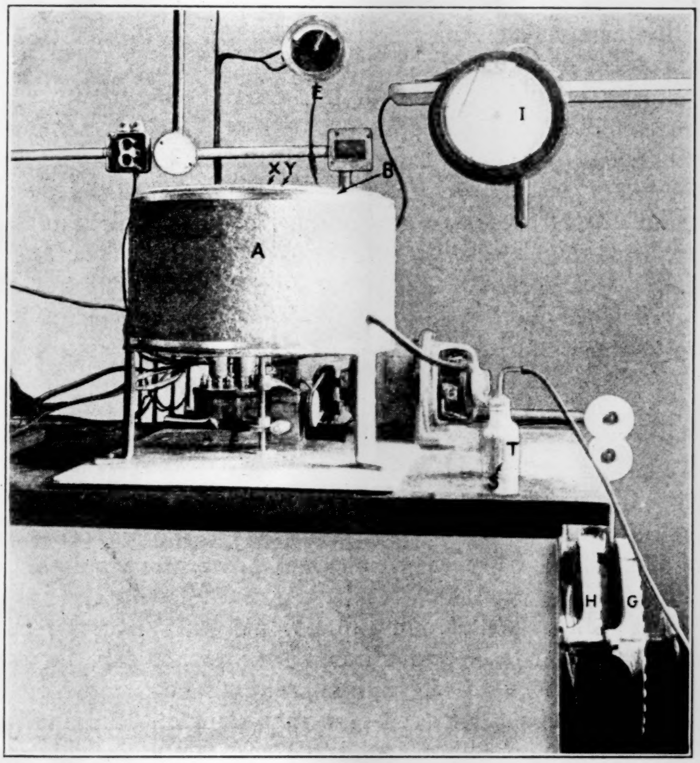

FIG. 1.—Apparatus for Determining Sludging Properties of Transformer Oils.

The beakers should be thoroughly washed using, first, benzol and finishing with a cleaning solution made as usual from potassium bichromate and sulfuric acid. The cleaning solution is thoroughly washed out with water, the beakers are dried in an oven and are then ready for use. The samples should be filtered through good quality filter paper. Five hundred cubic centimeters of each oil should be measured out and poured into the beakers. When the oven has come up to the operating temperature of 120° C., the lid is removed, the eight beakers with their oil samples put in place and the lid then replaced. The time at which the oil samples are placed in the oven is noted and considered as the beginning of the run. As the oxidation at this low temperature is quite slow, several days will elapse before any sedimentation occurs. Once a day the motor is stopped and the samples are examined by momentarily lifting a portion of the oil in a 15-cc. pipette which is inserted in the sampling hole, *X*. As soon as any sample is found to be near the sludging condition, 15 cc. of the oil are removed and placed in a graduated centrifuge tube having a tapering end. From this time on, daily specimens are withdrawn from the oils which are suspected of sludging. The specimens are properly labeled with the date and number of the sample, are allowed to stand over night and are centrifuged at 1800 revolutions per minute for twenty minutes. The tubes are then withdrawn and examined. The number of days which elapse before a sludge appears in a specimen is recorded as the time required to produce sludging of the transformer oil.

COMMENTS

An operator, after some experience with this method, will be able to judge fairly accurately from the darkening of the oil samples as to when they are approaching the sludging period. When starting with an unknown oil it may be necessary to remove samples quite early and frequently and then repeat the run, allowing it to proceed closely to the time when sludging first would start without removing samples. The point to be borne in mind of course is that the test will check more accurately with the minimum number of samples removed before sludging begins. In case the first sample withdrawn shows sediment. the tests must be repeated and earlier samples taken.

APPENDIX II

METHODS FOR DETERMINING SLUDGING PROPERTIES OF TRANSFORMER OILS

The following are the details of the procedures finally adopted for Michie, deposit (formalite) and tar number tests of transformer oil preliminary to the investigation of these methods referred to in the report of the main committee.

METHOD OF CARRYING OUT THE REVISED MICHIE TEST FOR TENDENCY OF TRANSFORMER OILS TO SLUDGE

(Based on Dr. A. C. Michie's test)

Apparatus:

(*a*) A 200-cc. round-bottomed boiling flask, approximately 76 mm. (3 in.) in diameter and 187 mm. (7⅜ in.) high, connected to

(*b*) A water or air cooled condenser. (An air condenser 250 mm. (10 in.) long, 25 mm. (1 in.) in diameter at one end and tapering to 13 mm. (½ in.) at the other is ample.) The upper portion of the air condenser is provided with

(*c*) A two-hole rubber stopper carrying

(*d*) Glass inlet and outlet tubes. The internal diameter of the inlet tube shall be 4.0 mm. (0.16 in.). It shall reach to within 3 mm. (0.12 in.) of the bottom of the flask. The outlet tube shall be of the same size as the inlet tube.

(*e*) A piece of unused pure sheet copper having a bright planished surface and measuring 51 by 32 by 0.01 mm. (2 by 1¼ by 0.004 in.) shall be prepared by rolling to form a tube, the two short sides being brought into close contact.

(*f*) The air from the equalizer shall pass first into a wash bottle containing a solution of sodium hydroxide (sp. gr. 1.355) through a glass inlet tube at least 8 mm. (⅓ in.) in internal diameter, ending 51 mm. (2 in.) below the surface, thence into a wash bottle containing a 10-per-cent silver nitrate solution through a glass inlet tube 4 mm. in internal diameter ending 51 mm. (2 in.) below the surface, thence into a wash bottle containing sulfuric acid through a glass inlet tube 4 mm. in internal diameter, ending 51 mm. (2 in.) below the surface, and then through a bottle containing dry asbestos fiber, the inlet tube extending to the bottom.

(*g*) Bubble counting bottle half filled with a light colored turbine or similar oil of approximately 0.880 sp. gr. with an inlet tube 4 mm. (0.16 in.) in diameter which shall dip 51 mm. (2 in.) below the surface of the liquid.

(*h*) An oil bath of any suitable material provided with a shelf of 6-mm. (¼ in.) mesh screen suspended at least 25 mm. (1 in.) above the bottom for supporting the flask and condenser. It may be heated by gas or electricity, and shall be provided with an automatic temperature regulating device (a recording thermometer is also useful) and some provision for stirring the oil so as to maintain a uniform temperature throughout the bath. Agitation with compressed air delivered through a glass tube 4 mm. (0.16 in.) in internal diameter to within 25 mm. (1 in.) of the bottom centrally and about one-fourth the length of the bath from one end at the rate of 15 to 20 bubbles per second, has been found sufficient to hold an average temperature throughout a bath 425 by 200 by 125 mm. (17 by 8 by 5 in.). Lagging with some heat insulating material around the sides is an advantage.

(*i*) An accurate testing gas meter reading to 0.1 liter.

(*j*) 25-cc. Gooch crucibles.

(*k*) No. 40 Whatman filter paper.

(*l*) Long fiber hydrochloric acid washed asbestos.

(For use, the Gooch crucible shall be packed with one sheet of filter paper and a thin pad, and about 1.5 mm. of the asbestos.)

(*m*) Glass beakers of at least 400-cc. capacity.

(*n*) Petroleum Spirit. This shall be water white in color. When distilled in accordance with the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (D 86 – 21 T) of the American Society for Testing Materials, and 50 per cent of the sample shall have been recovered in a graduated receiver, the thermometer shall not read higher than 110° C. (230° F.). The end point shall not be higher than 190° C. (374° F.).

(*o*) Uniform source of compressed air.

Procedure.—(*a*) One hundred cubic centimeters of the oil to be tested, which has been strained before measuring, through a dry 60-mesh brass or copper gauze to free it from sediment, shall be introduced into a clean, dry flask, at room temperature. When samples are taken from original packages, they should be placed in properly prepared tin cans and kept sealed until tested.

(*b*) One of the rolled strips of copper shall be placed in a vertical position in the bottom of the flask, and entirely submerged in the oil.

(*c*) The condenser with its inlet tube centrally in the copper tube reaching to within 3 mm. ($\frac{1}{8}$ in.) of the bottom of the flask, shall be attached to the flask by means of a cork stopper or a ground-in joint.

(*d*) Connect the inlet tube of the flask to the bubble counting bottle, the latter to the bottle of the washing train containing asbestos fiber, and the bottle of sodium hydroxide to the constant pressure air supply. Connect the outlet tube to the gas meter. If a gas meter be not continuously available, the uniformity of the quantity of air passing through the oxidizing flask may be controlled by placing a simple manometer and a piece of standardized capillary tubing in the air line between the washing train and the bubble counters. (About 150 mm. (6 in.) of a capillary of 0.328 to 0.344 mm. (0.013 to 0.015 in.) in internal diameter with a manometer made of 6-mm. tubing working under a pressure that causes a difference in elevation between the surfaces of the mercury of 40 mm. (1.6 in.), deliver the proper amount of air. However, each capillary shall be standardized exactly by shortening it until it delivers the proper rate of 2.0 liters per hour under the service conditions.)

(*e*) The whole of the bulb of the flask shall then be immersed in oil in the oil bath and clamped securely in position, taking care that no oil from the bath can enter the flask.

(*f*) The oil bath containing the test flask shall be maintained at a constant temperature of 150° C. (302° F.) ± 2° C. for 45 hours.

(*g*) During the period of heating, a current of air shall be passed through the oil in the flask at a constant rate of 2.0 liters (0.07 cu. ft.) per hour measured at laboratory temperature and pressure. The rate shall be adjusted by allowing it to pass through the bubble counting bottle at the rate of three bubbles a second. This rate shall be checked from time to time with a gas meter, or other accurate measuring device so placed in the air line as to exactly measure the volume of air passing through the oil under test in the flask.

(*h*) After the 45-hour treatment, the flask shall be disconnected and removed from the oil bath and allowed to cool below 40° C. (104° F.). The contents shall then be transferred to a beaker. The flask shall be washed out carefully several times with petroleum spirit with a swirling motion so that the copper may assist in the operation, being sure that all loose deposit is removed. The oil in the beaker shall be further diluted with an amount of petroleum spirit until the total of the latter is equal to three times the volume of the oil, and allowed to stand 12 hours or over night.

(*i*) The solution shall then be decanted to a prepared Gooch crucible. The loose sediment remaining in the beaker shall be washed onto the Gooch crucible with petroleum spirit. The deposit on the Gooch crucible shall then be thoroughly washed with petroleum spirit until free from oil, and dried at 100° C. for 2 hours. The result is expressed as a percentage thus:

$$\text{Percentage of sludge} = \frac{\text{weight of deposit in grams}}{\text{specific gravity of the oil}}$$

If an appreciable amount of gummy deposit or varnish remains in the flask or beaker, dissolve this out with benzol, collect it in an evaporating dish, evaporate to constant weight at 100° C., and report the percentage by the above formula as gummy deposit. In case benzol has not dissolved all gummy matter, repeat the operation with amyl acetate and report as such.

METHOD FOR CARRYING OUT DEPOSIT TEST FOR TRANSFORMER OIL

Apparatus:

(*a*) Buchner funnel, 5 cm. in diameter.

(*b*) Acid washed long fiber asbestos.

(*c*) 500-cc. flask.

(*d*) Petroleum Spirit. This shall be water white in color. When distilled in accordance with the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 - 21 T) of the American Society for Testing Materials, and 50 per cent of the sample shall have been recovered in a graduated receiver, the thermometer shall not read higher than 110° C. (230° F.). The end point shall not be higher than 190° C. (374° F.).

(*e*) Chemically pure sulfuric acid (sp. gr. 1.84).

(*f*) Chemically pure ammonium hydroxide (sp. gr. 0.900).

(*g*) Formaldehyde, 40-per-cent.

Procedure.—Dissolve 21.5 g. of the oil in 40 cc. of petroleum spirit in a 500-cc. flask. Add 10 cc. of sulfuric acid and shake vigorously for three minutes. Place the flask in a bath of ice water. Add 10 cc. of formaldehyde from a pipette, holding the tip against the side of the flask and adjusting the flow so as to cause the least amount of disturbance of the reaction layer, and give just enough agitation with the thermometer to keep the temperature of the reaction layer between 20 and 25° C. When there is no further indication of temperature rise, remove the flask from the bath and shake vigorously for three minutes. Allow to stand for 35 minutes at room temperature. Add 150 cc. of distilled water of room temperature and shake thoroughly until all of the precipitate is removed from the sides of the flask. Neutralize the acid to slight excess with ammonium hydroxide in presence of phenolphthalein, adding it in approximately 5-cc. portions and keeping the temperature below 30° C. Because of the quantity and condition in which the precipitate is thrown down from the 21.5-g. sample of some oils, making washing very difficult, more accurate and rapid determinations may be made by discarding such results and starting again with amounts as low as 5 g.

Prepare a small-holed Buchner funnel with a mat of asbestos weighing approximately 0.3 g. A thin strong mat may be produced by placing the weighed amount of asbestos (0.3 g.) in a beaker, covering it with 100 cc. of water and beating thoroughly to a homogeneous consistency. The contents of the beaker should be emptied at once into the funnel and allowed to drain five minutes without suction. Turn on the aspirator slowly and then to full force until the mat is sucked down tight. Dry the mat and funnel at 105° C. to constant weight and record. Start filtering off the precipitate, first releasing the pressure until there is just enough to draw the liquid through the filter. Too high vacuum with a heavy precipitate has a tendency to pack tightly on the mat and may slow up the process enough to interfere with the desirable rapidity. With a well-made mat and following the above procedure, the filtration and washing should be completed in thirty to forty-five minutes at the most. Should the filtrate show traces of precipitate or asbestos fibers, refilter until they disappear. Wash first with petroleum spirit to remove oil and then thoroughly with water to remove ammonia compounds. Dry the asbestos mat with the precipitate in the funnel at 105° C. to constant weight. From the dry weight of the precipitate the percentage of the deposit may be calculated.

METHOD FOR DETERMINING THE TAR NUMBER OF TRANSFORMER OILS (THE SO-CALLED "GERMAN 9") FROM REVISION DATED BERLIN, NOVEMBER, 1922, WITH A.S.T.M. ADDITIONS

Apparatus:

(*a*) 400-cc. Florence flasks provided with two-hole cork stoppers, inlet and outlet tubes, 3 mm. ($\frac{1}{8}$ in.) in inside diameter. The inlet tube shall extend to within 3 mm. ($\frac{1}{8}$ in.) of the bottom of the flask.

(*b*) 300-cc. Erlenmeyer flasks.

(*c*) Separatory funnels.

(*d*) Phillips or similar beakers.

(*e*) Oil bath heated by gas or electricity with thermostat control and suitable support for the large flasks. A recording thermometer is also desirable.

(*f*) Bubble counting bottles, of 4-oz. capacity, half filled with pale mineral oil of approximately 0.880 sp. gr., with inlet and outlet tubes 3 mm. ($\frac{1}{8}$ in.) in inside diameter. The inlet tube shall have its lower end 50 mm. (2 in.) below the surface of the oil.

(*g*) Compressed oxygen in tank with regulating valve.

(*h*) Alcoholic sodium hydroxide solution, 75 g. of sodium hydroxide in a mixture of 1000 g. of alcohol and 1000 g. of distilled water.

(*i*) Hydrochloric acid (sp. gr. 1.12).

(*j*) 90-per-cent Benzol leaving no residue on evaporation.

(*k*) Two wash bottles of $\frac{1}{4}$-liter capacity, high, cylindrical in shape, filled one-half their height with the wash liquid. One shall contain potassium hydroxide (sp. gr. 1.32), the other sulfuric acid (sp. gr. 1.84).

Procedure.—(*a*) Weigh 150 g. of the oil to be tested into a 400-cc. Florence flask. Immerse this in the oil bath so that the surface of the oil in the flasks is 20 to 25 mm. below that in the bath. Connect up the oxygen supply through the tell-tale bottle and into the flask. Heat the oil for 70 hours at 120° C. (248° F.), maintaining the temperature within ± 2° C., and pass warm oxygen through it at the rate of two bubbles per second during this time.

(*b*) Remove the Florence flask from the bath; cool. Thoroughly mix the sediment and oil, weigh out 50 g. into a 300-cc. Erlenmeyer flask, add 50 cc. of alcoholic sodium hydroxide solution, and heat on a boiling water bath with a reflux condenser for 20 minutes with occasional shakings. Remove the flask from the water bath, cover it with a cloth and agitate with a swirling motion for five minutes. After cooling, pour the contents into a separatory funnel. After the mixture has separated, draw off the lower layer and filter through filter paper. Transfer exactly 40 cc. of this filtrate to a second separatory funnel, add a few drops methyl orange, acidify with hydrocholric acid, add 50 cc. of benzol, and shake well. After the two layers have completely separated, draw off the aqueous layer into a third separatory funnel and wash with 25 cc. of benzol. Separate from the aqueous layer and add the benzol solution to that in the second separatory. Wash the benzol layer twice with 100 cc. of water each time. Transfer the benzol solution to a tared Phillips beaker, evaporate the benzol, dry the tar to constant weight at 100° C., and weigh.

$$\text{Tar Number} = \frac{\text{Weight of residue}}{40} \times 100$$

(*c*) When the oxidized oil is mixed ready for the addition of the sodium hydroxide solution, take 3 cc. from the Florence flask and add to 30 cc. of petroleum spirit in a separatory funnel, and shake to solution. Its behavior is reported as "clearly soluble" or "not clearly soluble."

(*d*) Empty the Florence flask in which oxidation was carried out and examine the flask as to the amount of varnish if any and reaction.

APPENDIX III

A METHOD OF MEASURING POWER FACTOR AND DIELECTRIC CONSTANT OF INSULATING MATERIALS AT COMMERCIAL FREQUENCIES

Several methods have been devised for making measurements of power factor and dielectric constant of insulating materials. The following method, which is used at the Electrical Testing Laboratories and which is very similar to a method used by the Westinghouse Electric and Manufacturing Co. has been found to be particularly convenient and accurate within commercial requirements, especially for measurements over a range of temperatures and at relatively high voltage stresses:

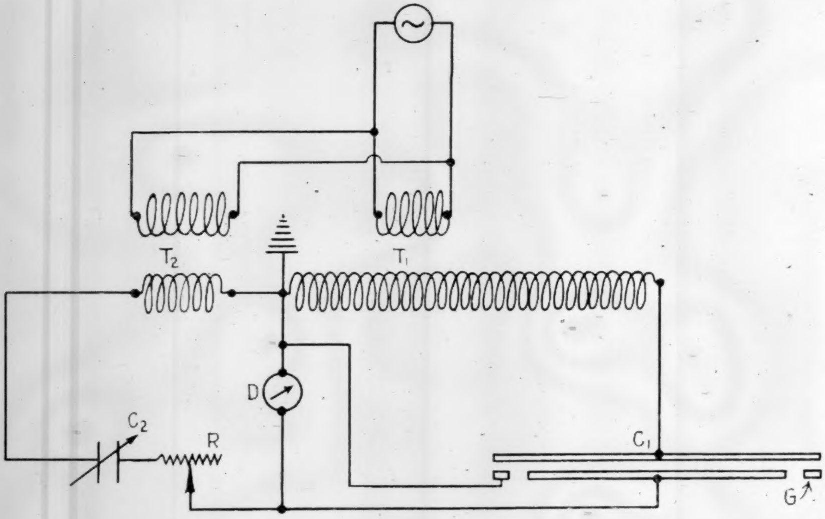

FIG. 1.—Schematic Diagram of Circuit for Determination of Power Factor and Dielectric Constant.

The bridge principle is employed, the sample being tested forming the dielectric of a condenser. Fig. 1 is a simple schematic diagram of the arrangement of the circuits where C_1 is a plate condenser in which the material to be tested is the dielectric, C_2 is an ordinary sub-divided standard mica condenser, R is a standard resistance box, T_1 is a transformer which supplies high voltage to the specimens, T_2 is a low voltage transformer and D is a detector. With the transformers so connected that the secondary coils are in opposition, the currents are made equal in magnitude and in phase (as indicated by zero indication of the detector) by adjusting C_2 and R. When this condition is established, the power factor and dielectric strength are calculated from the values of C_2 and R. The phase angles of the transformers are eliminated by first balancing either with air as the dielectric of C_1 or with an air condenser in place of C_1. In other words, the apparent power factor of the C_1 circuit is obtained before the material being tested is put in place and the corresponding correction is made in the final computation.

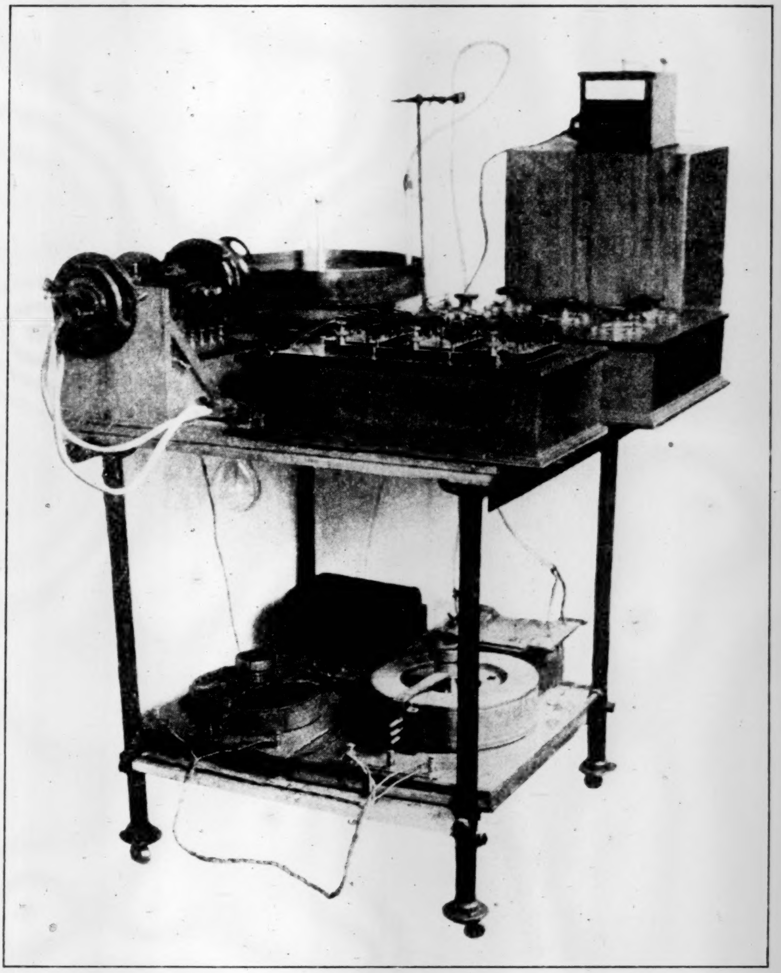

FIG. 2.—Photograph of Apparatus for Determination of Power Factor and Dielectric Constant.

Fig. 2 is a photograph of the apparatus. In this particular case T_1 is a standard 110 to 2200-volt potential transformer and T_2 is a 110 to 2.5-volt transformer that was originally used for another purpose. C_2 is a sub-divided one-microfarad standard condenser. The detector, D, is a synchronously-driven rectifying commutator with a direct current portable reflecting galvanometer. A vibration galvanometer or a separately excited electrodynamometer could also be used as a detector.

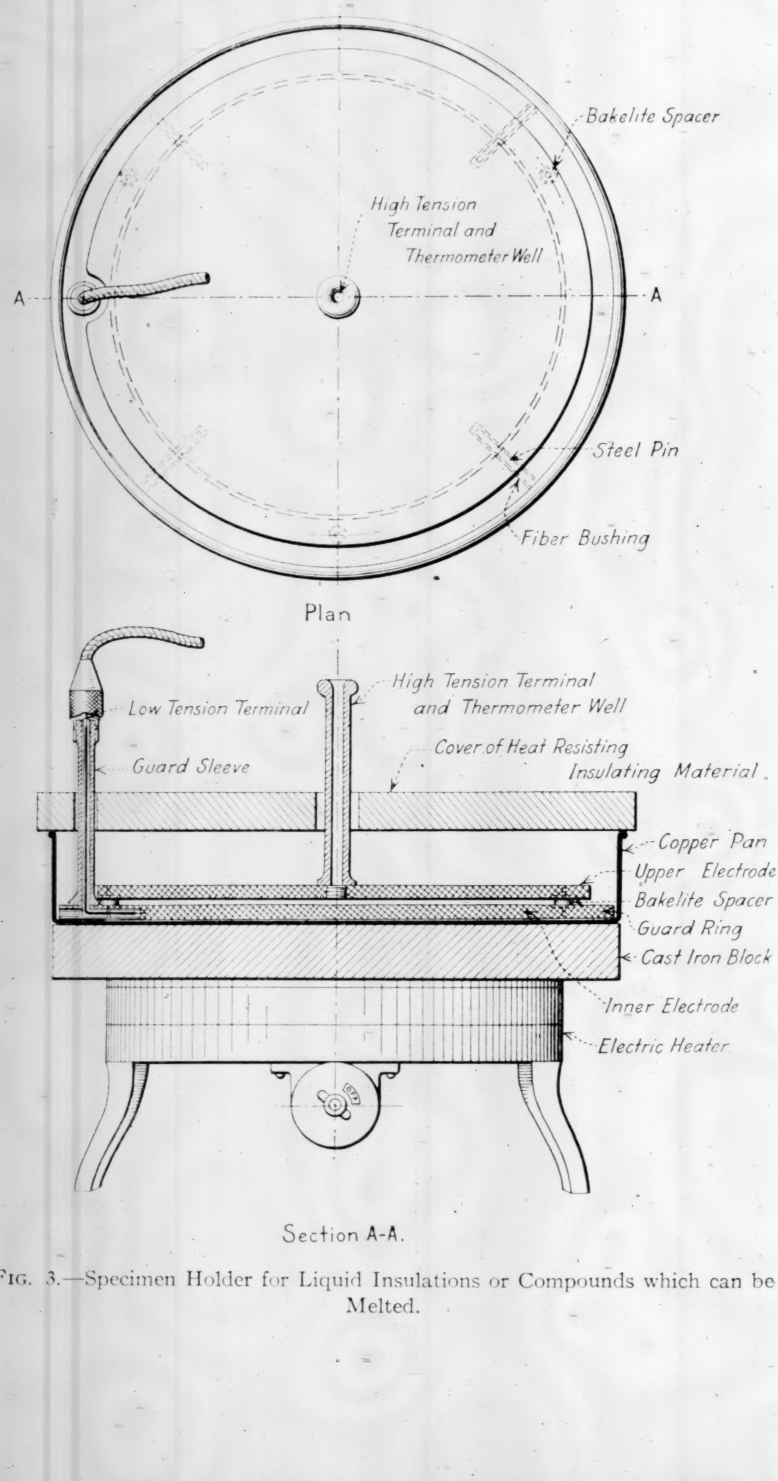
Bakelite Spacer
High Tension Terminal and Thermometer Well
A
A
Steel Pin
Fiber Bushing
Plan
Low Tension Terminal
High Tension Terminal and Thermometer Well
Guard Sleeve
Cover of Heat Resisting Insulating Material
Copper Pan
Upper Electrode
Bakelite Spacer
Guard Ring
Cast Iron Block
Inner Electrode
Electric Heater
Section A-A.

FIG. 3.—Specimen Holder for Liquid Insulations or Compounds which can be Melted.

The ratio of the secondary voltages may be of any value which will allow a balance to be obtained with the particular capacitances used, for example, at balance $C_1 \times E_1 = C_2 \times E_2$, where C_1 and C_2 are the capacitances of the two condensers C_1 and C_2, respectively, and E_1 and E_2 are the voltages of the transformers T_1 and T_2, respectively. With the particular condenser, C_1, shown in Fig. 2 and described in detail later, the capacitance with air is about 120 micro-microfarads which, with a ratio of T_1 to T_2 of 2200 : 2.5, requires about 0.1 microfarad in C_2 to balance the circuit. With the usual liquid insulations and compounds as the dielectric in C_1, the capacitance required in C_2 would be 0.2 to perhaps 0.3 or 0.4 microfarad.

Liquid Insulations and Compounds.—The construction of the specimen holder, that is, condenser C_1, used in Fig. 1 for liquid insulations or compounds which can be melted to a liquid form, is shown in Fig. 3. It consists of two circular copper or brass plates ⅜ in. thick separated about 0.2 in. by three short pieces of bakelite rod which rest on and are slightly recessed into the guard ring so that any leakage over them is not measured. The lower plate or electrode is 11 in. (27.9 cm.) in diameter and to it is attached a guard ring by means of radial steel pins insulated with fiber bushings. The upper electrode projects over the lower one.

The upper electrode is connected to the transformer through the terminal shown in Fig. 3 which serves also as a convenient means for handling the electrode and also as a thermometer well. The lower electrode is kept at ground potential and is connected to the measuring circuit through an insulated tube, as shown, on the outside of which is a metal guard sleeve. This latter is continued in the circuit by means of flexible metallic hose slipped over the wire.

The plates rest in a shallow copper pan which, in turn, is placed on a heavy cast-iron temperature equalizing plate, heated by means of an ordinary 12-in. disk type electric stove.

Care must be taken to exclude air bubbles from the space between the plates. The most convenient procedure is to put the lower plate in the pan, put in the required amount of material and then slip the upper plate into the liquid at an angle. After complete immersion it is slipped into place on the pins.

In the case of compounds which are solid at room temperature, they are heated to a temperature at which they are thin and then poured into the pan, the pan and plates being previously thoroughly heated to about the same temperature as the compound.

Sheet Materials.—In the case of sheet materials, mercury electrodes are used for the condenser plates instead of brass plates. A layer of mercury is poured on the bottom of the pan,[1] the specimens floated on the mercury and a pool of mercury in a hard rubber ring is placed on top of the specimen. A guard ring is provided in the form of mercury in an annular rubber ring around the upper electrode.

In this case the bottom electrode, being the high potential side, has to be insulated from the ground. This is readily accomplished by insulating the electric heater and only applying high potential when the heater is totally disconnected from the circuit. Experience has shown that where measurements are to be made at temperatures above room temperature and heating is necessary, the best procedure is to heat the sample to a temperature somewhat above the desired value and then to cut off the heat and take measurements as the sample cools. The apparatus cools very slowly so that there is ample time to take readings at any desired temperature as readings can be obtained very quickly. It is, however, to be noted that with this arrangement the heater should be totally disconnected from the circuit by means of a plug or similar device and not merely by means of the switch in the ordinary manner.

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[1] A separate tin pan is usually used in order to avoid amalgamating the copper pan.

With thin sheet materials the temperature of the two layers of mercury will be practically equal (and therefore that of the specimen) and can be measured with a thermometer in the top layer of mercury. With thick specimens, a thermocouple in each layer of mercury may have to be used in order to be sure that the two layers of mercury are at approximately the same temperature.

Results.—It will be found most convenient to use the resistance, R, in series with C_2 for values of $\tan \phi$ less than about 0.10 and in parallel for larger values of $\tan \phi$.

The dielectric constant of the material being tested is the ratio of the capacitance of the condenser with the material as the dielectric to that with air as the dielectric. The capacitance with the material is equal to the setting of the standard condenser, C_2, at balance divided by the ratio of the two secondary voltages (that is, the product of the ratios of the two transformers). This value for the capacitance will be correct for all values of $\tan \phi$ with the parallel connections of R. With the series connection, it is not strictly correct but the error is negligible for small values of $\tan \phi$, being less than 0.5 per cent at $\tan \phi$ equal to 0.1.

The capacitance with air as the dielectric may be obtained in the same manner. It may also be calculated from the dimensions by means of the following formula:

$$C = 2.246 \times 10^{-7} \times \frac{A}{d}$$

where C = capacitance in microfarads;
A = area of small electrode in square inches; and
d = distance between plates in inches.

Incidentally it should be noted that there should be no difficulty in getting an agreement of at least one per cent between the measured and calculated values of C_1 with air as the dielectric.

The power factor is computed from the values at balance of C_2 and R. With R in series with C_2 (for low power factors, that is, $\tan \phi$ less than 0.1), the apparent phase angle of C_2 (that is, the angle by which it departs from a theoretical angle of zero) is obtained from the relation:

$$\tan \phi = 2\pi fCR \times 10^{-6}$$

where ϕ = angle of departure from zero ($\cos(90-\phi)$ = power factor);
f = frequency in cycles per second;
C = capacitance of C_2 in microfarads; and
R = resistance of R in ohms.

With R in parallel with C_2 (for high power factors, that is, $\tan \phi$ greater than 0.1),

$$\tan \phi = \frac{10^6}{2\pi fCR}$$

where the symbols have the same significance as above.

REPORT OF COMMITTEE D-11

ON

RUBBER PRODUCTS

The committee has held two meetings during the year in addition to the one to be held during the present annual meeting of the Society. Both were held in New York City, one on November 14, 1922, and the other on March 21, 1923.

EXISTING TENTATIVE STANDARDS

Of the twelve tentative standards on rubber products now before the Society, the committee recommends continuing five in the present status, revising three and advancing four to standard as follows:

Tentative Specifications for Insulated Wire and Cable: 30-per-cent Hevea Rubber (D 27 - 21 T).—The unification of all American specifications on electric wires and cables has been undertaken by the American Engineering Standards Committee and a large committee, consisting of over 130 members, is now actively at work on the undertaking. Committee D-11 recommends, therefore, that this tentative standard be continued as tentative.

Tentative Specifications for Steam Hose (D 54 - 21 T).—The committee has under consideration a revision of these specifications but is not prepared to make a recommendation at this time.

Tentative Specifications for Adhesive Tape for General Use for Electrical Purposes (D 69 - 22 T), and

Tentative Specifications for Rubber Insulating Tape (D 119 - 22 T).—Although no criticisms have been received of either of these two specifications and no revisions are contemplated, the committee recommends that they be continued as tentative as it is desired to secure the formal comments of certain other organizations particularly interested in these materials before proposing that these specifications be made standard.

Tentative Methods of Testing Rubber Products (D 15 - 22 T).[1]—No criticism of these methods have been received but in view of the study being given to rubber testing methods by other organizations at the present time, it is recommended that these methods be continued as tentative for the present with the following revisions:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 947 (1922).

Section 61 (b).—Add a paragraph to read as follows:

"If the sample fails in this test, two additional samples shall be tested and if either of these fails, the entire lot of hose represented by the samples shall be considered to have failed to meet the specifications."

Add a new Section 62 to read as follows:

"*Other Types of Hose.*—In testing samples of other types of hose, the pressure shall be raised at the above rate until the prescribed pressure is reached and then held for the prescribed period, after which the pressure shall be increased at the same rate until failure occurs.

"If the sample fails in this test, two additional samples shall be tested and if either of these fails the entire lot of hose represented by the samples shall be considered to have failed to meet the specifications."

Tentative Specifications for Cotton Rubber-Lined Fire Hose for Private Fire Department Use (D 14 – 22 T).[1]—No criticisms of these specifications have been received by the committee and it is recommended that the specifications be adopted by the Society as standard, with the following minor revisions:

Section 7.—Change the first sentence of this section from its present form: namely,

"Samples shall be taken both as regards number and location at the discretion of the inspector."

to read as follows, so as to make it more definite:

"A sample not less than 8 in. in length shall be taken from each lot of 500 ft. of hose or less for the tests specified in Sections 8 and 9."

Section 8 (b).—Insert a tolerance of ±2° F. (1.1° C.) in the prescribed temperature of 158° F. (70° C.) for the dry heat test.

Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public Fire Department Use (D 26 – 21 T).[2]—No criticisms of these specifications have been received by the committee and it is recommended that they be adopted by the Society as standard with the following minor revisions:

Section 7.—Make the same change as in Section 7 of Specifications D 14 – 22 T above.

Section 8 (b).—Make the same change as in Section 8 (*b*) of Specifications D 14 – 22 T above.

Tentative Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not Exceeding 3000 Volts to Ground (D 120 – 22 T).[3]—These specifications have been recommended by the Accident Prevention Committee of the National Electric Light Association to the membership of the Association. No criticism has been received during the year and the committee now recommends that the specifications be advanced to standard.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 925 (1922).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 778 (1921).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 937 (1922).

Tentative Specifications for Rubber Pump Valves (D 151 – 22 T).[1] —No criticisms having been received of these specifications, it is recommended that they be advanced to standard.

Tentative Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 – 21 T).[2]—The following revisions are recommended in these specifications:

Section 6 (a).—Change from its present form: namely,

> "The wire armor shall be $\frac{3}{16}$ in. half-round galvanized steel wire, wrapped with $\frac{1}{4}$-in. space between adjacent turns."

to read as follows:

> "For hose 1 in. or less in diameter, the wire armor shall be $\frac{5}{32}$ by $\frac{1}{16}$-in. half-elliptical, galvanized mild steel wire wrapped with a maximum space of $\frac{3}{8}$ in. between adjacent turns. For hose over 1 in. in diameter, the wire armor shall be $\frac{3}{16}$ by $\frac{3}{32}$-in. half-round, galvanized mild steel wire wrapped with a maximum space of $\frac{3}{8}$ in. between adjacent turns. Any other size of half-elliptical or half-round wire of equal or greater area may be used provided neither dimension varies more than $\frac{1}{64}$ in. from that specified above."

Section 8.—Change to read as follows by the addition of the italicized words and figures and the omission of the word and figures in brackets:

> "A sample [52] *36* in. [long] *in length* shall be cut from each lot of 500 ft. of hose or less and subjected to the following tests."

Section 9.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "(*a*) *In the case of hose 1 in. or less in diameter, the* test specimens shall be cut longitudinally from the sample of *the* hose; *in the case of hose over 1 in. in diameter, the test specimens shall be cut transversely.*
>
> "(*b*) The tensile strength shall be not less than [1500] *800* lb. per sq. in. for the tube and [1300] *1000* lb. per sq. in. for the cover.
>
> "(*c*) The elongation at the breaking load [for both the tube and the cover] shall be such that the original 2-in. gage length of the test specimens shall stretch to not less than [10½ in.] *7 in. in the case of the tube and 9 in. in the case of the cover.*
>
> "(*d*) The set, or permanent elongation, following a stretch from 2 in. [to 9 in.] *to 5 in. in the case of the tube and from 2 in. to 7 in. in the case of the cover* shall not exceed 25 per cent."

Section 10.—Change from its present form: namely,

> "The adhesion between the plies shall be determined by suspending a 15-lb. weight from the separated end of a ply of a 1-in. test ring cut from the 52-in.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 944 (1922).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 784 (1921).

sample described in Section 8, the force being applied radially. The rate of separation of the plies shall be not greater than 1 in. per minute. The test shall extend for ten minutes when the size of the test ring permits."

to read as follows:

"The adhesion between plies shall be such that a weight of 18 lb. will not cause separation at a rate greater than 1 in. per minute. The adhesion between the cover and plies and also between the tube and the plies shall be such that a weight of 15 lb. will not cause separation at a rate greater than 1 in. per minute."

This change is recommended since the test procedure details now given in this section are superfluous, in view of the fact that they are covered in the standard procedure outlined in Methods D 15 – 22 T.

Section 11.—Change the first paragraph to read as follows by the addition of the italicized words and figures and the omission of the word and figures in brackets:

"From the [52-in.] *36 in.* sample, a piece of hose [3 ft.] *24 in.* long shall be taken and subjected to a hydrostatic test at the pressure specified in Table II for hose of its size."

Table II.—Change Table II on test pressures to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

TABLE II.—TEST PRESSURES

INSIDE DIAMETER OF HOSE, IN.	TEST PRESSURE, LB. PER SQ. IN.
$\frac{3}{8}$	[750] *700*
$\frac{7}{16}$	[725] *675*
$\frac{1}{2}$	[700] *650*
$\frac{5}{8}$	[650] *625*
$\frac{3}{4}$	[650] *625*
1	600
$1\frac{1}{8}$	[600] *575*
$1\frac{1}{4}$	[550] *575*
$1\frac{1}{2}$	550

Section 14.—Insert a new Section 14 to read as follows, re-numbering the subsequent sections accordingly:

"*Tolerances, Inside Diameter.*—The inside diameter shall vary not more than $\pm\frac{1}{64}$ in. from that specified in the case of $\frac{3}{8}$ to $\frac{3}{4}$-in. hose, inclusive, nor more than $\pm\frac{1}{32}$ in. from that specified for larger sizes."

Add a paragraph to the present Section 14 to read as follows:

"The letters and figures shall be $\frac{1}{4}$ in. high, shall stand $\frac{1}{32}$ in. in relief, and shall be clear and distinct."

Section 16.—The procedure covering failure as outlined in this section is covered in Methods D 15 – 22 T. It is accordingly recommended that this section be changed from its present form: namely,

"(*a*) If the sample fails to meet the requirements of Section 9, the lot from which it was taken shall be rejected.

"(*b*) If the sample fails to meet the requirements of either Section 10 or 11, two additional samples shall be tested. If either sample fails, the lot from which it was taken shall be rejected."

to read as follows:

"(*a*) Each length of hose that fails to meet any of the requirements of these specifications shall be rejected.

"(*b*) In the case of failure to pass any one of the tests specified in Sections 9, 10, and 11, the entire lot of hose represented by the sample, or samples, subjected to these tests shall be rejected."

The committee recommends that the specifications as revised be continued as tentative.

Tentative Specifications for Braided Air Hose for Use with Pneumatic Tools (D 60 - 21 T).[1]—The following revisions are recommended in these specifications:

Section 6 (a).—Make the same change as in Section 6 (*a*) of Specifications D 46 - 21 T above.

Section 8.—Make the same change as in Section 8 of Specifications D 46 - 21 T above.

Section 9.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"(*a*) *In the case of hose 1 in. or less in diameter, the* test specimens shall be cut longitudinally from the sample of *the* hose; *in the case of hose over 1 in. in diameter, the test specimens shall be cut transversely.*

"(*b*) The tensile strength shall be not less than 800 lb. per sq. in. for the tube and [700] *1000* lb. per sq. in. for the cover.

"(*c*) The elongation at the breaking load [for both the tube and the cover] shall be such that the original 2-in. gage length of the test specimens shall stretch to not less than [8 in. for the tube and 7 in. for the cover] *7 in. in the case of the tube and 9 in. in the case of the cover.*

"(*d*) The set, or permanent elongation, following a stretch from 2 in. [to 6 in.,] *to 5 in. in the case of the tube and from 2 in. to 7 in. in the case of the cover* shall not exceed 25 per cent [in either tube or cover]."

Section 10.—Change from its present form: namely,

"The adhesive quality of the rubber binding the plies together shall be determined by suspending a 15-lb. weight from the separated end of a ply of a specimen 1 in. wide, cut transversely from the 52-in. sample described in Section 8. The rate of separation of the plies shall be not greater than 1 in. per minute."

to read as follows:

"The adhesion between plies shall be such that a weight of 18 lb. will not cause separation at a rate greater than 1 in. per minute. The adhesion between the cover and plies and also between the tube and the plies shall be such that a weight of 15 lb. will not cause separation at a rate greater than 1 in. per minute."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 788 (1921).

Section 11.—Change the first paragraph to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"From the [52-in.] *36-in.* sample described in Section 8, a piece of hose [3 ft.] *24 in.* long shall be taken and subjected to a hydrostatic test at the pressure specified in Table I, for hose of its size."

Table I.—Change Table I on test pressures to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

TABLE I.—TEST PRESSURES

INSIDE DIAMETER OF HOSE, IN.	TEST PRESSURE, LB. PER SQ. IN.
$\frac{3}{8}$	[950] *800*
$\frac{7}{16}$	[925] *800*
$\frac{1}{2}$	[900] *800*
$\frac{5}{8}$	[850] *800*
$\frac{3}{4}$	[750] *800*
1	700
$1\frac{1}{8}$	650
$1\frac{1}{4}$	600
$1\frac{1}{2}$	550

Section 13 (a).—Change from its present form: namely,

"(*a*) The minimum wall thicknesses shall be $\frac{3}{32}$ in. for the rubber tube and $\frac{1}{16}$ in. for the rubber cover."

to read as follows:

"(*a*) The minimum thickness for the tube of $\frac{3}{8}$ and $\frac{7}{16}$-in. hose shall be 0.045 in.; for $\frac{1}{2}$ to $\frac{3}{4}$-in. hose, inclusive, the minimum thickness for the tube shall be 0.062 in., and for 1 to $1\frac{1}{2}$-in. hose, inclusive, the minimum thickness of the tube shall be 0.094 in. The minimum thickness for the cover of $\frac{3}{8}$ and $\frac{7}{16}$-in. hose shall be 0.045 in.; for $\frac{1}{2}$ to $1\frac{1}{2}$-in. hose, inclusive, the minimum thickness of the cover shall be 0.062 in."

Section 14.—Insert a new Section 14 to read as follows, re-numbering the subsequent sections accordingly:

"*Tolerances.*—The inside diameter shall vary not more than $\pm\frac{1}{32}$ in. from that specified in the case of $\frac{3}{8}$ to $\frac{3}{4}$-in. hose, inclusive, nor more than $\pm\frac{1}{16}$ in. from that specified for larger sizes."

Add a paragraph to the present Section 14 to read as follows:

"The letters and figures shall be $\frac{1}{4}$ in. high, shall stand $\frac{1}{32}$ in. in relief, and shall be clear and distinct."

Section 16.—Make the same change as in Section 16 of Specifications D 46 – 21 T above.

The committee recommends that the specifications as revised be continued as tentative.

Tentative Specifications for Rubber Belting for Power Transmission (D 53 - 21 T).[1]—It is recommended that these specifications be revised as follows and continued as tentative:

Section 10.—Add a new Paragraph (*b*) to read as follows:

> "(*b*) The adhesion between the plies shall be such that a weight of 20 lb. will not cause separation at a rate greater than 1 in. per minute."

Section 11.—Change the first sentence to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets.

> "A test specimen 20 in. in length and prepared as described in Section 9 shall have transverse reference lines marked upon it 10 in. apart and at equal distances from the ends; it shall then be tested in a tension testing machine and under a pull of 100 lb. per in. per ply, shall [not] stretch *not* more than [7] *9* per cent *nor less than 5 per cent.*"

Section 21.—Insert a new Section 21 to read as follows, re-numbering the subsequent section accordingly:

> "*Rejection.*—Any length of belting which fails to meet the requirements of these specifications shall be rejected."

PROPOSED NEW TENTATIVE STANDARDS

Proposed Tentative Specifications for Wrapped Cold Water Hose.—Proposed tentative specifications for wrapped cold water hose for other than fire department use are appended to this report[2] and are recommended for publication as tentative.

Proposed Tentative Specifications for Rubber Matting for Use Around Electrical Apparatus or Circuits not Exceeding 3000 Volts to Ground.—Proposed tentative specifications for rubber matting for use around electrical apparatus to meet the requirements of the electrical industry as represented by the Accident Prevention Committee of the National Electric Light Association have been prepared and are appended to this report.[3] It is recommended that they be published as a tentative.

MISCELLANEOUS

The principal activity of importance aside from work in connection with specifications has been in connection with the general subject of performance tests for rubber products. A special committee is studying this problem with a view to determining the practicability of introducing into specifications for rubber products performance tests such, for example, as certain kinds of abrasion tests and the Geer accelerated aging test.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 795 (1921).

[2] See p. 864.—ED.

[3] See p. 867.—ED.

The following is the result of the letter ballot vote of the committee, consisting of 33 members, on the recommendations made in this report:

Item	Affirmative	Negative	Not Voting
TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD			
Tentative Specifications for Cotton Rubber-Lined Fire Hose for Private Fire Department Use (D 14 – 22 T)	20	1	12
Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public Fire Department Use (D 26 – 21 T)	18	1	14
Tentative Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits not Exceeding 3000 Volts to Ground (D 120 – 22 T)	20	0	13
Tentative Specifications for Rubber Pump Valves (D 151 – 22 T)	20	2	11
PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Specifications for Wrapped Air Hose for Use with Pneumatic Tools (D 46 – 21 T)	18	2	13
Tentative Specifications for Braided Air Hose for Use with Pneumatic Tools (D 60 – 21 T)	19	1	13
Tentative Specifications for Rubber Belting for Power Transmission (D 53 – 21 T)	23	0	10
Tentative Methods of Testing Rubber Products (D 15 – 22 T)	31	0	2
PROPOSED NEW TENTATIVE STANDARDS			
Proposed Tentative Specifications for Wrapped Cold Water Hose	21	1	11
Proposed Tentative Specifications for Rubber Matting for Use Around Electrical Apparatus or Circuits not Exceeding 3000 Volts to Ground	22	1	10

This report has been submitted to letter ballot of the committee, which consists of 33 members, of whom 24 have voted affirmatively, none negatively, and 9 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. FARMER,
Chairman.

C. B. MARTIN,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Cotton Rubber-Lined Fire Hose for Private Fire Department Use; and the Tentative Specifications for Cotton Rubber-Lined Fire Hose for Public Fire Department Use, both amended as indicated in this report; the Tentative Specifications for Rubber Gloves for Electrical Workers on Apparatus or Circuits Not Exceeding 3000 Volts to Ground; and the Tentative Specifications for Rubber Pump Valves were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on August 28, 1923, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1923.

The proposed revisions of the Tentative Specifications for Wrapped Air Hose for Use with Pneumatic Tools; for Braided Air Hose for Use with Pneumatic Tools; for Rubber Belting for Power Transmission; and of the Tentative Methods of Testing Rubber Products, referred to in this report, were accepted for publication as tentative. The tentative standards as revised appear on pages 852–863 and 870, respectively.

The proposed Tentative Specifications for Wrapped Cold-Water Hose; and the proposed Tentative Specifications for Rubber Matting for Use Around Electrical Apparatus or Circuits Not Exceeding 3000 Volts to Ground were accepted for publication as tentative and appear on pages 864–869.

DISCUSSION

[Mr. Vassar presented on behalf of Committee D-11 the proposed Tentative Specifications for Rubber Matting for Use Around Electrical Apparatus on Circuits Not Exceeding 3000 Volts to Ground for publication as tentative.—Ed.]

Mr. Ellis Mr. A. E. Ellis.[1]—Referring to the proposed Tentative Specifications for Rubber Matting, in Section 2 mention is made of cotton fabric, but no requirements are included for the weight or kind that should be used. It seems to me that in order to make the specifications complete, some definite weight of cotton duck should be specified and included in the specifications. I would recommend that a cotton duck, commonly known as 8-oz. cotton duck, be considered by the committee as a suitable backing for the rubber matting.

Mr. Vassar Mr. H. S. Vassar[2] (*Secretary of Committee D-11*).—I will simply say that the matter of including requirements for the cotton fabric insert was considered. It seems a little difficult to get ideas together that will be generally acceptable to users and manufacturers. I think the suggestion is a good one that this be included; at the same time, the omission need not stand in the way of the acceptance of the proposed tentative specification, because it can be inserted if necessary after we have had a year's trial of the specification and received comments from manufacturers and users.

[The motion to accept the proposed Tentative Specifications was approved.—Ed.]

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[1] Chief Chemist, Interborough Rapid Transit Co., New York City.

[2] Laboratory Engineer, Public Service Electric Co., Irvington, N. J.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS

Committee D-13 on Textile Materials held two meetings during the past year. The fall meeting was held in New Bedford, Mass., October 27 and 28, 1922, the first session in the Convention Hall of the New Bedford Hotel, and the second session in the hall of the Fairhaven Mills. The spring meeting was held in Providence, R. I., the first session at the Providence Biltmore Hotel, and the second session in the rooms of the Providence Engineering Society. Both of these meetings were well attended by members, and there was a large attendance of guests representing various cotton manufacturing organizations in the vicinities in which these meetings were held. At the fall meeting the time was principally taken up in a discussion of preliminary reports from the sub-committees. These discussions resulted in recommendations to the sub-committees for continuation of the work and complete reports were submitted at the springm eeting.

Proceeding along the lines followed in the development of the Specifications for Imperfections and Tolerances for Square-Woven Builder Fabric, Specifications for Imperfections and Tolerances for Cord Tire Fabrics have been developed and are being presented as appended to this report[1] for approval as a tentative standard.

Discussion of the present Tentative Specifications for Imperfections and Tolerances for 60-in. 17¼-oz. Square-Woven Builder Fabric (D 122 - 22 T)[2] has led to a revision of these specifications, broadening their scope to include square-woven tire fabrics other than 60-in. 17¼-oz. to which the present specifications are limited. This revision involves a number of changes both in the form and substance of the specifications, and they have accordingly been appended in full in their revised form for acceptance to remain tentative for another year.

"Specifications for Tolerances and Test Methods for Yarns and Cords" including single and plied yarns as submitted by Sub-Committee VII on Yarn, Thread and Twine, were the subject of considerable discussion, and at the March meeting were accepted for submission to the Society as a tentative standard. They are appended hereto[3] and the committee recommends that they be accepted for publication as tentative. The need for these Test Methods and Tolerances for Yarns and Cords has been long felt, and it is hoped that the specifications proposed will prove of value.

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[1] See p. 894.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 967 (1922).

[3] See p. 898.—Ed.

A new sub-committee has been organized during the past year for the development of specifications for ducks other than tire fabrics including hose, belt, tent, army, enameling, sail and numbered ducks. This sub-committee includes seven representatives of duck manufacturers, seven consumers of these fabrics, and three organizations which neither manufacture nor consume the fabrics under consideration. This sub-committee IX on Hose, Belt and Numbered Duck has developed Specifications for Tolerances for Hose Ducks and Belt Ducks as appended hereto[1] which are submitted by Committee D-13 to the Society for approval as a tentative standard.

In considering the use of the Standard General Methods of Testing Cotton Fabrics (D 39 - 20) as test methods for fabrics included in the proposed Specifications for Tolerances for Hose Ducks and Belt Ducks, it was thought desirable to propose specific test methods for these and similar ducks as provided in Section 1 of the Standard General Methods of Testing Cotton Fabrics, and accordingly Committee D-13 proposes for publication as tentative Specific Test Methods for Ducks, Including Hose, Belt, Tent, Army, Enameling, Sail and Numbered Ducks to be appended to the Standard General Methods of Testing Cotton Fabrics as indicated in the revisions of the Standard Methods outlined below. Committee D-13 recommends the following revisions in the present Standard General Methods of Testing Cotton Fabrics (D 39 - 20):[2]

Title.—Change the title to read as follows by the omission of the word in brackets:

"Standard [General] Methods of Testing Cotton Fabrics."

Section 1.—Add a central heading immediately preceding this section to read as follows:

"General Test Methods."

Fig. 2.—Change Fig. 2, illustrating the "grab test," so as to show the strip 6 by 4 in. in size, and showing the jaws 3 in. apart.

Table I.—Change the dimensions of specimen for the grab test given in Column 2 of the table from 5 by 2 in. to 6 by 4 in.; change the distance between jaws for the grab method from 1 in. to 3 in.

Change the Diagram No. 2 so as to show a width of fabric of 22 in. instead of 12 in. and showing specimens 6 by 4 in. in size instead of 5 by 2 in.

Table II.—Add a reference under the column headed "Humidity Conditions" opposite "ducks, including hose duck, belt duck, tent duck, army duck, enameling duck, sail duck, numbered duck," to read "See Section 16."

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[1] See p. 902.—ED.

[2] 1921 Book of A.S.T.M. Standards.

The present notes (*a*) and (*b*) in the column headed "Humidity Conditions" are to apply only to Drill, Sheeting, Osnaburg, Coutils, and Balloon Cloth.

Add six new sections to read as follows under the new central heading "Specific Test Methods":

TEST METHODS FOR DUCKS, INCLUDING HOSE, BELT, TENT, ARMY, ENAMELING, SAIL AND NUMBERED DUCKS

"14. All test procedure not covered in these specific methods, shall be in accordance with the foregoing General Methods of Testing Cotton Fabrics.

"15. *Sampling.*—From each delivery of 1000 yd. or fraction thereof, samples of not more than 2 linear yd. each shall be cut from any part of at least 2 rolls for test purposes.

"16. *Humidity Conditions.*—Tests may be made under prevailing atmospheric conditions, except in the settlement of disputes concerning weight and strength. In such case, tests shall be made upon material having normal moisture content obtained by exposure for at least 4 hours to an atmosphere of 65 per cent relative humidity at a temperature of 70° F.

"17. *Weight.*—In case any dispute arises in regard to weight, the weight per square yard shall be determined from the actual average width, the invoiced yardage (verified when necessary), and the actual weight of the entire bolt or roll. The results of tests on one or two yards for width and weight shall not be used alone as a basis for rejection.

"18. *Threads per Inch.*—(*a*) The count shall be determined by ascertaining the number of threads in 3 in., taken consecutively and reducing to the number of threads per inch.

"(*b*) The warp count shall be determined at five different places not less than 8 in. from either selvage for materials 26 in. or over in width; for materials under 26 in. in width, it shall not be taken nearer the selvage than one-fourth of the entire width of the fabric.

"(*c*) The filling count shall be determined at five places about equidistant throughout the roll, midway between the selvages and not within ten yards of either end.

"19. *Strength.*—(*a*) The tensile strength shall be determined on an approved type of inclination balance breaking machine. The maximum capacity of the machine shall be 800 lb.

"(*b*) The 1 by 1 by 3-in. grab method of testing shall be used, defined as follows:

"The lower half of each pair of jaws shall be 2 in. or more in width, and the upper half shall be 1 in. in width. (The jaws shall be planed smooth and flat, with edges slightly rounded to prevent cutting.) The initial length of the test pieces between the jaws of the testing machine shall be 3 in., and the pulling jaw shall travel at a uniform rate of 12 in. per minute. Ten test pieces, 6 in. in length by 4 in. in width, shall be cut, five in the direction of the warp and five in the direction of the filling, respectively. Care shall be taken that no two test pieces include the same threads. The average result of the tests shall be recorded separately for warp and filling. No sample for testing shall be taken at less than 8 in. from either selvage for materials 26 in. or over in width, or for materials under 26 in. at less than one-fourth of the entire width of the fabric. If the width of the materials does not admit of cutting pieces as stated above, they shall be taken as near the center as possible.

"In the case of a break evidently below the general average for the fabric, a second test on the same threads shall be made and this test shall then be used in obtaining the average result."

During the past year eight new members have been enrolled in Committee D-13.

The recommendations contained in this report have been submitted to letter ballot of the committee consisting of fifty-seven members, with the following results:

Items	Affirmative	Negative	Not Voting
Submission of Proposed Tentative Specifications for Imperfections and Tolerances for Cord Tire Fabrics	33	4	20
Submission of Proposed Tentative Specifications for Tolerances and Test Methods for Cotton Yarns and Cords	34	5	18
Submission of Proposed Tentative Specifications for Tolerances for Hose Ducks and Belt Ducks	32	5	20
Revision of the Standard General Methods of Testing Cotton Fabrics (D 39 – 20)	32	5	20
Revision of the Tentative Specifications for Imperfections and Tolerances for 60-in. $17\frac{1}{4}$-oz. Square-Woven Builder Fabric (D 122 – 22 T)	28	4	25

This report has been submitted to letter ballot of the committee, which consists of 57 members, of whom 37 have voted affirmatively, none negatively, and 20 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. E. JURY,
Chairman.

RUSSELL T. FISHER,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard General Methods of Testing Cotton Fabrics, referred to in this report, were accepted for publication as tentative and appear on page 973.

The proposed revisions of the Tentative Specifications for Imperfections and Tolerances for 60-in. $17\frac{1}{4}$-oz. Square-Woven Builder Fabric were accepted. The specifications as revised appear on page 890.

The proposed Tentative Specifications for Imperfections and Tolerances for Cord Tire Fabrics; the proposed Tentative Specifications for Tolerances and Test Methods for Cotton Yarns and Cords; and the proposed Tentative Specifications for Tolerances for Hose Ducks and Belt Ducks were accepted for publication as tentative and appear on pages 894–904.

REPORT OF COMMITTEE D-14

ON

SCREEN WIRE CLOTH

Committee D-14 has held four meetings since it last reported to the Society. These meetings have been concerned principally in the formulation of the proposed Tentative Specifications for Non-Ferrous Insect Screen Cloth which are being presented at this time.

These specifications were prepared jointly by Sub-Committee I on Wire for Weaving and Sub-Committee II on Manufacture of Wire Screen Cloth and cover two classes of non-ferrous insect screen cloth—one of pure copper and the other of a 90 copper-10 zinc alloy known as "Commercial Bronze." It is intended to add a nickel alloy class to the specifications, but sufficient data could not be obtained to incorporate this at this time.

The diameter of the wires to be used for the various weights of cloth has caused considerable discussion and controversy, chiefly because of the different sizes used by the several manufacturers and the adherence of some to the Old English gage. The diameters of the wires proposed in the tentative specifications represent a compromise, but are based upon the American Wire Gage (B & S).

It has not been deemed advisable at this time to include specifications for the physical properties of the wires used in weaving screen cloth for the reasons stated in the note accompanying the specifications.

It is now proposed to set out exposure test panels in various parts of the country to determine the relative life of cloth produced in accordance with the tentative specifications under differing atmospheric conditions. This work will be in charge of Sub-Committee IV on Testing.

Committee D-14 recommends that the Society accept for publication as tentative the Tentative Specifications for Non-Ferrous Insect Screen Cloth appended hereto.[1] The result of the letter ballot of the committee on this recommendation is as follows: Affirmative, 14; negative, 1; not voting, 1.

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[1] See p. 591.—Ed.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 13 have voted affirmatively, 1 negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

R. W. WOODWARD,
Chairman.

W. H. BASSETT,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Non-Ferrous Insect Screen Cloth, referred to in this report, with the modifications given in the Summary of Proceedings, page 15, were accepted for publication as tentative and appear on page 591.

REPORT OF COMMITTEE D-15
ON
THERMOMETERS

Committee D-15 was created to study the question of temperature measurements within the range of mercury in glass thermometers as they may occur in the Society's specifications and methods of test and to give particular attention to the numerous specifications for thermometers, both tentative and standard. Heretofore, there has been no systematic means for correlating the specifications adopted by the various committees and some of the specifications may have been written without the direct advice or representation of the producers of thermometers. One of the objects to be attained in the formation of Committee D-15 was to secure direct representation of manufacturers of thermometers, as the basis of the Society's work has always been to have both producers and consumers represented on committees having to do with the formulation of standards.

The first duty of the committee after its organization was evidently to survey the general field of temperature measurements that are required in the various A.S.T.M. standards and tentative standards. This survey showed that out of a total of 160 standard specifications, there were 231 references to temperature measurements in 72 standards, and of 133 tentative standards there were 219 references to temperature measurements in 65 tentative standards, so that in nearly one-half of our standards and tentative standards, temperature measurements are of some importance.

The committee then studied the existing thermometer specifications. A summary of these is given in Table I. There were seven specifications that were standard and six that were tentative.

It will be noted that in several cases the thermometers as specified by the different committees, with the exception of a few minor requirements, are so closely alike that a single thermometer might well serve to replace a number of our existing standards. This would result in a very considerable saving in cost due to the fact that the manufacturers would not have to carry so many different styles and would furthermore be able to manufacture in larger quantities. Aside from the matter of cost, the use of fewer standards would be a very great convenience in laboratories where a considerable variety of work is handled as it would save stocking so many different types of thermometers.

The majority of the existing thermometer specifications are for thermometers that are calibrated at total immersion and yet it will be noted in studying the general subject of temperature requirements as they are applied in our standards and tentative standards, that with very few exceptions the temperature must be measured in such a manner that only a portion of the thermometer may conveniently be immersed in the material to be tested. In other words, in practically all of our tests the thermometers are used as partial immersion thermometers.[1]

It will be noted that in connection with a great number of temperature measurements called for in our standard and tentative specifications, no thermometers have been specified and to cover this work, the committee felt that there was need of several standardized types of thermometers that would be of sufficient accuracy for such general use and would also be suitable for adoption as standards in any test where their design was applicable.

TABLE I.—SUMMARY OF THERMOMETER SPECIFICATIONS APPEARING IN A.S.T.M. STANDARDS

Serial Designation	Use	Calibration	Range	Divisions	Length, mm.	Marking
			STANDARDS			
D 6 - 20	Loss on Heating	Total immersion	150–175° C.	1° C.	152.4	None
D 12 - 16	Heating Test	Total immersion	210–310° C.	2° C.	115.0	None
D 12 - 16	Heating Test	Total immersion	100–400° C.	1° C.	.....	Optional
D 20 - 18	Road Materials	Total immersion	0–400° C.	1° C.	385.0	A.S.T.M. Distillation
D 36 - 21	Softening Point, Asphalts	....	30–160° C.	0.5° C.	400.0	None
D 36 - 21	Softening Point, Asphalts	....	0– 80° C.	0.2° C.	400.0	None
D 38 - 18	Creosote Oil	Total immersion	0–400° C.	1° C.	385.0	A.S.T.M. Distillation
D 56 - 21	Flash Point	57 mm.	20–230° F.	1° F.	275.0	A.S.T.M. P. M. and Tag
D 61 - 20	Softening Point, Pitch	Total immersion	0– 80° C.	0.2° C.	400.0	None
			TENTATIVE STANDARDS			
D 13 - 21 T	Turpentine	Total immersion	145-200° C.	0.2° C.	150	None
D 86 - 21 T	Gasoline	Total immersion	30–580° F.	2° F.	381	A.S.T.M. Low Distillation
D 86 - 21 T	Gasoline	Total immersion	30–760° F.	2° F.	381	A.S.T.M. High Distillation
D 87 - 21 T	Paraffin Melting Point	$3\frac{1}{8}$ in.	80–160° F.	0.2° F.	368	A.S.T.M. Paraffin Melting Point
D 92 - 21 T	Open Flash	1 in.	20–760° F.	5° F.	305	A.S.T.M. Open Flash
D 93 - 21 T	Pensky Martens	57 mm.	20–230° F.	1° F.	275	A.S.T.M. P.M. and Tag
D 93 - 21 T	Pensky Martens	57 mm.	200–700° F.	5° F.	275	A.S.T.M. P.M. High Distillation
D 97 - 21 T	Cloud and Pour Test	$4\frac{1}{2}$ in.	−36–+120° F.	2° F.	222	A.S.T.M. Cloud and Pour

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[1] It may be explained at this point that in calibrating a thermometer it has been the general custom to immerse the thermometer completely (that is, all of the mercury thread) in the calibrating liquid. If the thermometer is not so immersed and if any of the mercury in the stem is exposed beyond the bath, then the thermometer is said to be used at partial immersion and when so used, the indications of the thermometer are lower than the true temperature, when this temperature is above that of the emergent mercury column.

In the consideration of the most suitable types of thermometers the committee was greatly aided by the work that has been in progress by the Manufacturing Chemists' Association and the American Chemical Society, a number of members of Committee D-15 having been members of the committee of the Manufacturing Chemists' Association.

The committee, therefore, recommends three standard types of thermometers as tentative standards[1] for general use where no thermometer is specified and for adoption as standards where their design is suitable. These thermometers are all of the partial immersion type and cover the ranges from −20 to +150° C. or 0 to 300° F.; −5 to +300° C. or +30 to +580° F.; and −5 to +400° C. or +20 to +760° F.

These specifications have been arrived at after very extended consideration both by the manufacturers and users of thermometers in cooperation with the U. S. Bureau of Standards.

In preparing these specifications, special attention has been given to their form. It has been the aim of the committee to develop a form of specification which should be intelligible to the purchaser of the thermometer and acceptable to the manufacturer. This form of specification was developed with the idea that ultimately all of the society's specifications for thermometers could be put in a standard form.

The standardization of a partial immersion thermometer is ordinarily not as definite as the standardization of a total immersion thermometer because the temperature of the emergent mercury column is determined by the conditions under which the standardization is effected. Unless these conditions are controlled or specified, it may readily happen that a standardization made at one time or place may differ from another standardization, so that two standardized partial immersion thermometers, placed side by side in the same bath, might differ appreciably. It is possible, however, to specify the conditions under which the standardization is to be carried out, and with such specifications to make the standardization nearly as definite as for a total immersion thermometer, with the result that two standardized partial immersion thermometers, made according to a given specification, should yield identical results if used side by side. If the conditions under which the thermometers were used were such that the average temperature of the emergent column differed markedly from the stem temperature for which they were standardized, the observed temperatures might differ somewhat from the temperature of the bulbs.

In proposing the three standardized partial immersion thermometers referred to above, the committee has also provided for their standardization, thus making it possible to produce partial immersion thermometers which, under given conditions, will give as consistent readings as could be obtained with total immersion thermometers, but with the advantage that the readings of the partial immersion thermometers will differ but little from true temperatures.

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[1] See pp. 905–910.—ED.

The committee has also, at the request of Committee D-2 on Petroleum Products and Lubricants, prepared specifications for a set of thermometers for use with the Saybolt viscosimeter. These specifications have also been put in the standard form adopted by the committee and are recommended to Committee D-2 for approval for inclusion in its Method of Test for Viscosity.[1]

The committee invites suggestions and criticisms of the work accomplished, to the end that direct service can be rendered the standing committees on specific problems during the coming year.

The proposed specifications recommended for publication as tentative were approved by the committee and sent out to letter ballot with the following results:

Items	Affirmative	Negative	Not Voting
PROPOSED NEW TENTATIVE STANDARDS			
1. Proposed Tentative Specifications for A.S.T.M. Partial Immersion Thermometers, −20 to +150° C., 0 to +300° F.	10	0	1
2. Proposed Tentative Specifications for A.S.T.M. Partial Immersion Thermometers, −5 to +300° C., +20 to +580° F.	9	1	1
3. Proposed Tentative Specifications for A.S.T.M. Partial Immersion Thermometers, −5 to +400° C., +20 to +760° F.	9	1	1
4. Proposed Specifications for A.S.T.M. Thermometers for Use with Saybolt Viscosimeter to be sent to Committee D-2	11	0	0

This report has been submitted to letter ballot of the committee, which consists of 11 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

E. F. MUELLER,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for A.S.T.M. Partial-Immersion Thermometers, −20 to +150° C., 0 to +300° F.; the proposed Tentative Specifications for A.S.T.M. Partial-Immersion Thermometers, −5 to +300° C., +20 to +580° F.; and the proposed Tentative Specifications for A.S.T.M. Partial-Immersion Thermometers, −5 to +400° C., +20 to +760° F., referred to in this report, were accepted for publication as tentative and appear on pages 905–910.

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[1] See p. 672.—ED.

REPORT OF COMMITTEE E-1
ON
METHODS OF TESTING

Committee E-1 on Methods of Testing has continued during the year the activities begun with its reorganization two years ago and outlined in considerable detail in the last annual report.[1] It will be recalled that the committee has adopted a procedure in considering the methods of test prepared by the various standing committees, which in brief is a study of methods from the broad viewpoint of the test as a type of test that may be made upon a wide variety of materials and comprising eventually the formulation of fundamental considerations that govern the various kinds of testing. Obviously, the development of such a broad program is a question of time, and while gratifying progress is being made along certain lines, the committee at the same time is endeavoring to pass as promptly as possible upon tentative methods of test as they are submitted by the standing committees. The committee calls attention to its statement of a year ago that it does not intend to withhold indefinitely approval of tentative methods that standing committees may desire to see advanced to the status of standard, pending a study of the fundamental principles underlying the various kinds of tests involved in specific methods. The committee does, however, reserve the privilege of reviewing methods thus advanced to standard and submitting criticisms at some future time.

The policy of studying methods from a broad viewpoint will lead to the organization of permanent sub-committees to consider tests of a certain type, such as, tension, compression, distillation, classification of material according to size, etc. Certain of these sub-committees have been organized, as indicated later. A classification of the Society's methods of test according to type of test was included in the last annual report and appears again on page 484.

It is gratifying to observe that careful preparation of methods of test by the standing committees has been very much in evidence during the past year. Several committees have carefully reviewed methods submitted a year ago and a number of new methods representing considerable study and effort are being brought forward this year. The form of methods of test suggested by Committee E-1 and now a part of the Regulations Governing the Form of Standards, is proving helpful to the standing committees in arranging methods of test in logical order, and as the standing committees become more familiar with this form it is expected that wherever applicable it will be very generally used, in the same way that the form of specifications adopted eight or nine years ago is now practically universally used by our committees. The helpful cooperation between standing committees in developing similar methods of test, urged by Committee E-1 for the past two years, has also been evident and in some instances Committee E-1 itself has been the means through which such cooperation has been attained.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 501 (1922).

Certain discussions during the year have shown that consideration of methods of test would be greatly facilitated if original test data that served as a basis in the formulation of the methods were available. The committee is accordingly suggesting to the Executive Committee of the Society the desirability of requiring that standing committees include in their reports the principal data upon which methods of test have been based.

The committee wishes to announce the appointment by the Executive Committee of the Society of F. G. Breyer as a member-at-large of Committee E-1 and a member of the Advisory Committee, to succeed A. E. Jury, who was obliged to resign because of pressure of other work.

An administrative question worthy of mention has to do with the modification of the rules governing the deliberations of the committee. The work ahead of Committee E-1 is so voluminous and far-reaching as to have made it evident that the requirement in the rules as announced last year that the chairman of each of the sub-committees of Committee E-1 should be a member of the Advisory Committee would soon prove to be impractical and unworkable without considerable enlargement of the Advisory Committee, which, from an administrative point of view, has not seemed desirable. The rules of the committee have therefore been revised so that sub-committees reviewing methods of test submitted by the standing committees will consist of at least one representative member from each standing committee affected by the method of test and a chairman who will be designated by the Advisory Committee. It is the intention of the Advisory Committee to secure as the chairmen of the various sub-committees properly qualified members of the Society, if necessary outside of the immediate personnel of Committee E-1 by enlisting them as "advisers" of the committee. It is believed that this ruling will greatly facilitate the business of the committee. The vote of the committee on the adoption of this revision was as follows: Advisory Committee, 7 affirmative, 0 negative, 0 not voting, total, 7; Standing Committees, 33 affirmative, 0 negative, 2 not voting, total, 35.

Since the last annual meeting, the Advisory Committee has held two meetings at the Society headquarters, on November 17, 1922, and February 16, 1923. The regular fall meeting of the main committee was cancelled and the committee met February 16. The Advisory Committee will meet again during the present annual meeting.

CLASSIFICATION OF METHODS OF TEST

As previously mentioned, the committee published last year a classification of the Society's methods of test giving the titles of sixteen groups which had been tentatively adopted, with a list of the several kinds of tests included. For convenience this classification is repeated and appears as Table I.

Reference should be made to the committee's discussion last year of the work under these various groups. The following further progress in certain of these groups is here reported:

I. Methods of Mechanical Tests Made by Application of Stress-Producing Forces.—For the present this group is being developed with respect to metals, by a sub-committee under the chairmanship of H. F. Moore consisting of representatives of the several committees of the Society dealing with metals. The work of this sub-committee in the revision of the present Standard Methods of Mechanical Testing of Metallic Materials (E 1 – 18), described in detail later in the report, will, it is believed, serve as a basis for the development of fundamental principles regarding the types of tests in this group.

II. Methods of Mechanical Tests Involving such Properties as Consistency, Plasticity, etc.—The appointment of a representative sub-committee, under the chairmanship of A. T. Goldbeck, to consider the tests in this group was announced in the report a year ago. At that time emphasis was laid upon the confusion that now exists in the use of such terms as "consistency," "plasticity" and "workability," and that a discussion of the term "consistency" had brought out several ideas as to its meaning. The sub-committee has been endeavoring to arrive at a suitable definition for this term in order that it could discuss more intelligently the methods of determining this property. In order to obtain discussion that will be of help in its further work, Committee E-1, at the suggestion of the sub-com-

TABLE I.—CLASSIFICATION OF A.S.T.M. METHODS ACCORDING TO TYPE OF TEST

- I. Mechanical Tests made by Application of Stress-producing Forces. (See also II.)
  - Tension.
  - Compression.
  - Crush.
  - Flattening.
  - Bend.
  - Fracture.
  - Homogeneity.
  - Flange.
  - Splitting.
  - Hydrostatic.
  - Brinell Hardness.
  - Impact.
  - Abrasion.
  - Friction.
  - Beading.
- II. Mechanical Tests Involving such Properties as Consistency, Plasticity, etc. (Closely related to I.)
  - Consistency.
  - Plasticity.
  - Workability.
  - Viscosity.
  - Ductility.
  - Softening Point.
  - Melting Point.
  - Penetration.
- III. Tests for Density, Refractive Index and Similar Physical Constants. (See also V in relation to Porosity.)
  - Density and Specific Gravity.
  - Unit Weight.
  - Refractive Index.
- IV. Classification of Material. (Including separation of materials, impurities, etc.)
  - Mechanical Separation.
  - Percentage of Waste.
  - Colorimetric Tests.
  - Determination of Foots.
  - Precipitation Number.
- V Tests for Absorptive Properties. (See also III.)
- VI. Tests for Determination of Water.
- VII. Tests for Constancy of Volume.
- VIII. Tests for Time of Setting.
- IX. Thermal Tests.
  - (Cast-Iron Wheels.)
  - Chill Test.
  - Fire Test of Materials.
  - Freezing and Thawing.
  - Spalling Action.
  - Slagging Action.
  - Fusion.
  - Fusibility.
  - Cloud and Pour Tests.
  - Heating Test (Jellying of Tung Oil)
  - Digester Test.
- X. Test for Volatility.
  - Distillation.
  - Loss on Heating.
  - Flash and Fire Point.
- XI. Metallographic Tests.
- XII. Magnetic Tests.
- XIII. Dielectric Tests.
- XIV. Miscellaneous Tests of a Chemical Nature.
  - Free Carbon
  - Soluble Bitumen.
  - Matter Insoluble in Benzol.
  - Alcohol Insoluble Matter.
  - Carbon Residue.
  - Determination of Ash.
  - Free Sulfur.
  - Discoloration of Copper.
  - Tinning Test.
  - Iodine Number.
  - Polymerization.
  - Determination of Acid.
  - Saponification Number.
  - Unsaponifiable Matter.
  - Strain Test.
  - Determination of Rosin.
- XV. Color.
- XVI. Dimensional Measurements.
  - Measurements.
  - Crimp and Off-square.

mittee, recommended to the Society's Committee on Papers and Publications that there be arranged at this annual meeting a Symposium on Consistency. Such a Symposium is being arranged and the sub-committee will submit as its contribution a resumé of definitions of "consistency" and related properties, and methods of test, including the apparatus used, that have been adopted by or are in general use in the several committees of the Society. It is desired through this paper, first, to make available results of research conducted by the committees during the year and, second, to present to the Society an account of the difficult problems which the sub-committee is facing.

Further, it has seemed desirable to Committee E-1 that some consideration should be given to the fundamentals underlying the properties of materials that are designated by the terms "consistency," "workability," etc. The committee has therefore suggested that the Symposium be introduced by a suitable paper discussing these fundamentals.

IV. Methods of Classification of Material (*Including Separation of Materials, Impurities, etc.*).—The mechanical separation of materials, including grading and the determination of fineness, is an important test applied to a number of materials being studied by the standing committees. Its importance has been emphasized by a formal communication to the Society from the U. S. Bureau of Public Roads, referred to Committee E-1 for its consideration, calling attention to considerable confusion in road testing laboratories throughout the country because of the several different standards for sieves in the Society and elsewhere. The Bureau has urged that this work be taken up vigorously by the Society. It would appear that the first step in this direction is to bring about uniformity in the Society's own specifications and methods, and accordingly the committee presents in the accompanying Table II the principal requirements of sieves in the various Society's standards, and a comparison of these requirements with those of four types of sieves in more or less general use, namely, the U. S. Bureau of Standards, Tyler, Ludlow-Saylor, and Howard and Morse.

The organization of a sub-committee to handle this subject is now under way. F. G. Breyer, a member of the Advisory Committee, has accepted the responsibility of the chairmanship and it is hoped that substantial progress can be made in the next year.

VI. Methods of Test for Determination of Water.—A sub-committee under the chairmanship of W. H. Fulweiler has made considerable progress in harmonizing methods for determination of water

TABLE II.—COMPARISON OF SIEVE SPECIFICATIONS

Number or Mesh[1]		Bureau of Standards	Tyler Scale	Ludlow-Saylor	Howard and Morse	Standard Specifications and Tests for Portland Cement C 9-21	Standard Specifications for Natural Cement, C 10-09	Standard Method of Test for Softening Point of Fire-Clay Brick, C 24-20	Standard Method of Test for Sieve Analysis (C 41-22)	Standard Method of Mechanical Analysis of Sand, (D 7-18)	Tentative Methods of Testing Rubber, (D 15-22T)
200	Opening, in.	0.0029	0.0029	....	0.0028	0.0029	....	....	....	0.0029	....
	Wire, in.	0.0021	0.0021	....	0.0022	0.0019–0.0023	....	....	....	0.0021	....
190	Opening, in.	....	....	....	0.0031	....	....	....	....	....	....
	Wire, in.	....	....	....	0.0022	....	....	....	....	....	....
180	Opening, in.	....	....	....	0.0031	....	....	....	....	....	....
	Wire, in.	....	....	....	0.0024	....	....	....	....	....	....
170	Opening, in.	0.0035	0.0035	....	0.0033	....	....	....	....	....	....
	Wire, in.	0.0025	0.0024	....	0.0026	....	....	....	....	....	....
160	Opening, in.	....	....	....	0.00345	....	....	....	....	....	....
	Wire, in.	....	....	....	0.0028	....	....	....	....	....	....
150	Opening, in.	....	0.0041	....	0.0036	....	....	....	....	....	....
	Wire, in.	....	0.0026	....	0.003	....	....	....	....	....	....
140	Opening, in.	0.0041	....	0.00424	0.0039	....	....	....	....	....	....
	Wire, in.	0.0029	....	0.0029	0.0032	....	....	....	....	....	....
130	Opening, in.	....	....	0.00439	0.0041	....	....	....	....	....	....
	Wire, in.	....	....	0.0033	0.0036	....	....	....	....	....	....
120	Opening, in.	0.0049	....	0.00463	0.0046	....	....	....	....	....	....
	Wire, in.	0.0034	....	0.0037	0.0036	....	....	....	....	....	....
115	Opening, in.	....	0.0049	....	....	....	....	....	....	....	....
	Wire, in.	....	0.0038	....	....	....	....	....	....	....	....
110	Opening, in.	....	....	0.00509	0.005	....	....	....	....	....	....
	Wire, in.	....	....	0.0040	0.004	....	....	....	....	....	....
100	Opening, in.	0.0059	0.0058	0.0056	0.0055	....	95–101 openings 93–103 per in.	...	0.0059	0.0055	....
	Wire, in.	0.0040	0.0042	0.0044	0.0045	....	0.0042–0.0048	....	0.0040	0.0046	....
90	Opening, in.	....	....	0.0063	0.006	....	....	....	....	....	....
	Wire, in.	....	....	0.0048	0.005	....	....	....	....	....	....
80	Opening, in.	0.0070	0.0069	0.0070	0.00675	....	....	....	....	0.0067	....
	Wire, in.	0.0047	0.0056	0.0055	0.00575	....	....	....	....	0.0059	....
70	Opening, in.	0.0083	....	0.0073	0.0078	....	....	....	....	....	....
	Wire, in.	0.0055	....	0.0070	0.0065	....	....	....	....	....	....
65	Opening, in.	....	0.0082	....	....	....	....	....	....	....	....
	Wire, in.	....	0.0072	....	....	....	....	....	....	....	....
60	Opening, in.	0.0098	....	0.0092	0.009	....	....	0.0098	....	....	....
	Wire, in.	0.0064	....	0.0075	0.0075	....	....	0.0073	....	....	....
50	Opening, in.	0.0117	....	0.0110	0.011	....	....	....	0.0117	0.0114	....
	Wire, in.	0.0074	....	0.0090	0.009	....	....	....	0.0074	0.0083	....
48	Opening, in.	....	0.0116	....	....	....	....	....	....	....	....
	Wire, in.	....	0.0092	....	....	....	....	....	....	....	....
45	Opening, in.	0.0138	....	0.0127	....	....	....	....	....	....	....
	Wire, in.	0.0087	....	0.0095	....	....	....	....	....	....	....

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[1] The figures appearing in this column are the designations of the sieves. In the case of the Bureau of Standards Scale, Specifications C 9, Specifications C 10, and Methods C 41, they represent numbers, in the case of the Tyler Scale, Ludlow-Saylor and Howard and Morse sieves, Methods C 24, Methods D 7 and Methods D 15, they represent mesh.

TABLE II.—COMPARISON OF SIEVE SPECIFICATIONS—*Continued*

Number or Mesh[1]		Bureau of Standards	Tyler Scale	Ludlow-Saylor	Howard and Morse	Standard Specifications and Test for Portland Cement C 9 - 21	Standard Specifications for Natural Cement C 10-09	Standard Method of Test for Softening Point of Fire-clay Brick (C 24 - 20)	Standard Method of Test for Sieve Analysis (C 41-22)	Standard Method of Mechanical Analysis of Sand (D 7 - 18)	Tentative Methods of Testing Rubber (D 15 - 22 T)
40	Opening, in..	0.0165	...	0.0146	0.01475	....	....	....	....	0.0142	40 meshes per in.
	Wire, in.....	0.0098	....	0.0104	0.01025	....	....	....	....	0.0157	0.010
35	Opening, in..	0.0197	0.0164	0.0168	0.01732	....	....	....	....	....	....
	Wire, in.....	0.0114	0.0122	0.0118	0.01125	....	....	....	....	....	....
30	Opening, in..	0.0232	....	0.0205	0.02108	29.5–30.5 openings 28.5–31.5 per in.	....	....	0.0232	0.0197	....
	Wire, in.....	0.0130	....	0.0128	0.01225	0.0105–0.0115	....	....	0.0130	0.0130	....
28	Opening, in..	....	0.0232	....	....	....	....	....	....	....	
	Wire, in.....	....	0.0125	....	....	....	....	....	....	....	....
25	Opening, in..	0.0280	....	....	....	....	....	....	....	....	....
	Wire, in.....	0.0146	....	....	....	....	....	....	....	....	....
24	Opening, in..	....	....	0.0277	0.02795	....	....	....	....	....	....
	Wire, in.....	....	....	0.014	0.01375	....	....	....	....	....	....
22	Opening, in..	....	....	0.0305	....	....	....	....	....	....	....
	Wire, in.....	....	....	0.015	....	....	....	....	....	....	....
20	Opening, in..	0.0331	0.0328	0.0340	0.0335	19.5–20.5 openings 19.0–21.0 per in.	....	....	....	0.0335	20 meshes per in.
	Wire, in.....	0.0165	0.0172	0.016	0.0165	0.0160–0.0170	....	....	....	0.0157	0.016
18	Opening, in..	0.0394	....	0.0386	0.0368	....	....	....	....	....	....
	Wire, in.....	0.0189	....	0.017	0.01875	....	....	....	....	....	....
16	Opening, in..	0.0469	....	0.0445	0.0420	....	....	....	0.0469	....	....
	Wire, in.....	0.0213	....	0.018	0.0205	....	....	....	0.0213	....	....
14	Opening, in..	0.0555	0.046	0.051	0.0485	....	....	....	....	....	....
	Wire, in.....	0.0240	0.025	0.020	0.023	....	....	....	....	....	....
12	Opening, in..	0.0661	....	0.060	0.0583	....	....	....	....	....	....
	Wire, in.....	0.0272	....	0.023	0.025	....	....	....	....	....	....
10	Opening, in..	0.0787	0.065	0.075	0.073	....	....	....	....	0.079	....
	Wire, in.....	0.0299	0.035	0.025	0.027	....	....	....	....	0.022	....
8	Opening, in..	0.0937	0.093	0.097	0.0955	....	....	....	0.0937	....	....
	Wire, in.....	0.0331	0.032	0.028	0.0295	....	....	....	0.0331	....	....
7	Opening, in..	0.111	....	....	....	....	....	....	....	....	....
	Wire, in.....	0.036	....	....	....	....	....	....	....	....	....
6	Opening, in..	0.132	0.131	0.132	0.131	....	....	....	....	....	....
	Wire, in.....	0.040	0.036	0.035	0.035	....	....	....	....	....	....
5	Opening, in..	0.157	....	0.159	....	....	....	....	....	....	....
	Wire, in.....	0.044	....	0.041	....	....	....	....	....	....	....
4	Opening, in..	0.187	0.185	0.203	0.201	....	....	....	0.187	....	....
	Wire, in.....	0.050	0.065	0.047	0.049	....	....	....	0.050	....	....
3½	Opening, in..	0.223	....	....	....	....	....	....	....	....	....
	Wire, in.....	0.057	....	....	....	....	....	....	....	....	....
3	Opening, in..	0.265	0.263	0.279	....	....	....	....	....	....	....
	Wire, in.....	0.065	0.070	0.054	....	....	....	....	....	....	....
2½	Opening, in..	0.315	....	....	....	....	....	....	....	....	....
	Wire, in.....	0.073	....	....	....	....	....	....	....	....	....
2	Opening, in..	....	....	0.437	....	....	....	....	....	....	....
	Wire, in.....	....	....	0.063	....	....	....	....	....	....	....

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[1] The figures appearing in this column are the designations of the sieves. In the case of the Bureau of Standards Scale, Specifications C 9, Specifications C 10. and Methods C 41, they represent numbers, in the case of the Tyler Scale, Ludlow-Taylor and Howard Morse Sieves, Methods C 24, Methods D 7 and Methods D 15, they represent mesh.

in certain bituminous materials and petroleum products. Two tentative methods had been presented to the Society and published, one by Committee D-2 on Petroleum Products and Lubricants entitled: Tentative Method of Test for Water in Petroleum Products (D 95 - 21 T), and the second by Committee D-4 on Road and Paving Materials entitled: Tentative Method of Test for Water in Bituminous Materials (D 114 - 21 T). Through the efforts of this sub-committee these two methods have been harmonized and Committees D-2 and D-4 have joined in recommending for publication this year as tentative a Method for Determination of Water in Petroleum Products and Other Bituminous Materials. This method has been approved by formal letter ballot vote of Committee E-1 as follows: Advisory Committee, 7 affirmative, 0 negative, 0 not voting, total, 7; Standing Committees, 25 affirmative, 1 negative, 9 not voting, total, 35.

Another committee of the Society, Committee D-7 on Timber, is interested in this method of test in connection with analysis of creosote oil. The method is for the determination of water *per se*, which is of particular importance for the products studied by Committees D-2 and D-4; whereas in the case of creosote oil, such a determination is not an important factor. The Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 18) contain a method of dehydration, which is simply a step in the distillation of creosote oil and as such is a satisfactory method of determining the amount of water. The proposed method, while applicable to creosote oil, involves the use of a solvent, which would render the sample unsuitable for the further test of distillation. Committee E-1 will, however, endeavor to secure the approval of Committee D-7 for the proposed method as a suitable one for determination of water *per se* in creosote oil.

There are certain other methods in the Society dealing with the determination of water, namely, as applied to turpentine, shellac and red lead, gypsum, coal and coke, fabrics and determination of water and sediment in petroleum products. The sub-committee will be suitably enlarged to consider these tests.

X. Methods of Tests for Volatility.—During the year the sub-committee on this subject, under the chairmanship of A. W. Dow, has been concerned principally with the methods for distillation now tentative or standard in several methods of the Society. The unifying and simplifying of apparatus used in the distillation test has been given further consideration. Certain collaborative work between Committees D-2 on Petroleum Products and Lubricants, D-4 on

Road and Paving Materials and D-7 on Timber is being done and it is hoped that the results of these tests when completed will enable the sub-committee to make definite recommendations. (Committee D-1 on Preservative Coatings has decided that the work being carried out by Committee D-2 is sufficiently representative as to make it unnecessary for Committee D-1 to undertake any of the collaborative work.) One of the principal points of discussion is the use of the distillation flask and the distillation retort. The fact that the distillation test is used for different purposes, namely, for fractional distillation and destructive distillation, is being given due consideration.

Some further consideration has been given to the question of flash point tests and it has been tentatively concluded that it may be necessary to have at least two types of closed testers, one for light volatile products and one for heavy products.

XI. Methods of Metallographic Tests.—The committee has delegated to Committee E-4 on Metallography the preparation of methods of metallographic tests. Methods of Metallographic Testing of Iron and Steel (E 3 – 21 T) are being supplemented this year by Tentative Methods of Metallographic Testing of Non-Ferrous Metals and Alloys contained in the annual report of Committee E-4.

XII. Methods of Magnetic Tests.—In a similar way, methods of magnetic tests have been delegated to Committees A-6 on Magnetic Properties and A-8 on Magnetic Analysis. The former committee is proposing as tentative this year a revision of the Society's Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 18), in the form of a new standard which will supersede, when adopted, the present standard methods.

TENTATIVE METHODS OF TEST

There is given below as a matter of record the titles of tentative methods of test that are now published by the Society. These are classed into three groups: those first submitted before 1921, those first submitted in 1921, and those first submitted in 1922. It has not been possible for Committee E-1 to study all of these methods, although a good deal has been done with some of them in studying certain general considerations and in reviewing their form and arrangement. As will be seen, a number of these methods are special and of interest only to special groups. Those marked with an asterisk are being recommended for advancement to standard this year. The Methods of Testing Gypsum and Gypsum Products (C 26 - 21 T) and the Method of Shatter Test for Coke (D 141 – 22 T) have received general consideration by the committee (the latter test having been discussed in a general way by the recently organized Sub-Committee on Impact Testing) and Committee E-1 has voted to interpose no objection to the advancement of these methods to the status of standard, reserving the privilege of submitting criticisms and recommendations at some later time when there has been opportunity to review these methods more carefully. The committee has not reviewed the Test for Fusibility of Coal Ash (D 22 – 22 T). This is a test highly special in character that has been prepared by those who are expert in coal analysis and it has been before the Society for several years as tentative. Committee E-1 has at this time no comments to make and its form and arrangement are satisfactory.

SUBMITTED BEFORE 1921

Tests for Compressive Strength of Cement Mortars, C 9 – 16 T

Slagging Action of Refractories, C 17 – 19 T

*Testing Gypsum, C 26 – 21 T

Specific Gravity of Road Oils and Tars, D 70 – 20 T

Specific Gravity of Asphalts and Tar Pitches, D 71 – 20 T

Clay in Sand-Clay, D 73 – 20 T

*Fusibility of Coal Ash, D 22 – 22 T

SUBMITTED IN 1921

Resistance of Fire-Clay Brick to Spalling Action, C 38 – 21 T

Compression Tests of Concrete, C 39 – 21 T

Securing Specimens of Hardened Concrete, C 42 – 21 T

Distillation of Gasoline, etc., D 86 – 21 T

Viscosity of Fuel Oils, D 88 – 21 T

Sulfur in Naphthas, D 90 – 21 T

Precipitation Number of Lubricating Oils, D 91 – 21 T

Flash and Fire Points by Open Cup, D 92 – 21 T

Saponification Number, D 94 – 21 T

Water in Petroleum Products, D 95 – 21 T

Water and Sediment in Petroleum Products, D 96 – 21 T

Cloud and Pour Points, D 97 – 22 T

SUBMITTED IN 1922

Sampling, Inspection, Packing and Marking of Quicklime, C 50 – 22 T

Melting Point of Petrolatum, D 127 – 22 T

Analysis of Grease, D 128 – 22 T

Sulfur in Heavy Petroleum Oils, D 129 – 22 T

Detection of Sulfur in Gasoline, D 130 – 22 T

Decantation Test for Sand, D 136 – 22 T

Mechanical Analysis of Subgrade Soils, D 137 – 22 T

Consistency of Concrete D 138 – 22 T

Float Test for Bituminous Materials, D 139 – 22 T

Sampling Bituminous Materials, D 140 – 22 T

*Shatter Test for Coke, D 141 – 22 T

Testing Small Specimens of Timber, D 143 – 22 T

SUBMITTED BEFORE 1921	SUBMITTED IN 1921	SUBMITTED IN 1922
	Ductibility of Bituminous Materials, D 113 – 22 T	Testing Felted or Woven Fabrics for Use in Waterproofing, D 146 – 22 T
	Water in Bituminous Materials, D 114 – 21 T	Testing Bituminous Mastics, D 147 – 22 T
	Insulating Varnishes, D 115 – 22 T	Sampling Bituminous Materials, D 148 – 22 T
	Electrical Porcelain, D 116 – 21 T	Test for Dielectric Strength of Sheet Insulating Materials, D 149 – 22 T
	Transformer and Switch Oils, D 117 – 21 T	Phase Difference of Molded Electrical Insulating Materials, D 150 – 22 T
	Testing Textiles, D 76 – 22 T	Testing Rubber Products, D 15 – 22 T
	Metallographic Testing of Iron and Steel, E 3 – 21 T	Testing Cotton Fibers, D 152 – 22 T

REVISION OF STANDARD METHODS OF MECHANICAL TESTING OF METALLIC MATERIALS (E 1 – 18)

Considerable progress has been made by the sub-committee under the chairmanship of H. F. Moore that has been charged with the revision of the Methods of Mechanical Testing of Metallic Materials (E 1 – 18). Committee E-1 submitted with its report last year, for information, Definitions of Terms Relating to Methods of Testing and Methods for Verification of Testing Machines, these comprising suggested revisions of the corresponding portions of Methods E 1 – 18. A number of criticisms and suggestions regarding these Definitions and Methods for Verification were received during the year and carefully considered. Some changes have been made, principally in the definitions of "stress" and "strain" and in the definitions that appear in the Methods for Verification, and the committee now recommends that the Definitions of Terms Relating to Methods of Testing and Methods for Verification of Testing Machines, as revised and appended hereto,[1] be accepted by the Society for publication as tentative. The letter ballot vote of the committee on this recommendation is as follows: Advisory Committee, 7 affirmative, 0 negative, 0 not voting, total, 7; Standing Committees, 32 affirmative, 0 negative, 3 not voting, total, 35.

The change in the definitions of "stress" and "strain" deserves a word of comment. In examining the definitions of "stress" given in various authoritative text-books, two definitions were found.

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[1] See pp. 911 and 937.—ED.

Text-books in physics and some European text-books in mechanics of materials gave a definition substantially the same as the committee now recommends, that is, "The intensity per unit area of the internal force, which, in the presence of forces causing a change in the form of a body, tends to hold the particles in their original relation and to preserve the integrity of the body." American text-books in engineering mechanics define "stress" as a *force*, measured in pounds, and they call the intensity of force "unit stress" or "fiber stress." This was the form of definition suggested last year. In view of the fact that even in engineering text-books the term "stress" is often used to denote intensity of force per unit of area, and in view of the fact that the physicists' definition involves somewhat simpler terms, the latter have been followed by the committee. Similarly, "strain" has been defined as "The change per unit of length in the linear dimension of a body, which change accompanies a given stress." Here again the physicists' point of view has been followed, as distinguished from the usual definition in engineering text-books in which "strain" is used in the sense of total deformation. The proposed definitions of "stress" and "strain" are followed by adequate notes explaining the committee's point of view. Such definitions as "stress-strain diagram," "elastic limit," "yield point," "tensile strength" and "modulus of elasticity" have been modified only to the extent required by revision in the definitions of "stress" and "strain."

As new work during the past year, this sub-committee has undertaken the revision of the Methods of Tension Testing of Metallic Materials as they appear at present in Standard Methods E 1 – 18. A complete revision has been prepared and is appended hereto. These methods include recommended test specimens and gripping devices, with suitable illustrations. Requirements for the operation of the testing machine are given, including pulling speed, and directions are given for the measurement of elongation and reduction of cross-section. Pending certain investigations now being made, the committee has made no revisions in the pulling speeds at present recommended in Methods E 1 – 18.

The committee does not feel that it is yet prepared to recommend these revisions for publication as tentative. It wishes, therefore, to submit them as a report of progress. They have been transmitted to each standing committee in the Society concerned with tension testing of metals and it is expected that a number of helpful comments will be received for consideration during the coming year. At the annual meeting in 1924 the committee hopes to be able to submit these methods, with such revisions as are decided upon, to the Society with the recommendation that they be adopted as standard. During the year the committee also hopes to be able to recommend to the proper standing committees that illustrations of tension test specimens and directions having to do with methods of tension testing shall be deleted from the various specifications for metals and that in their place an appropriate reference shall be made to the Methods of Tension Testing of Metallic Materials now being developed by Committee E-1.

As new business during the year the committee will take up the revision of the methods of hardness tests of metals (upon which considerable progress has already been made) and revisions of the methods of compression and transverse testing.

MISCELLANEOUS ANNOUNCEMENTS

Sub-Committee on Impact Testing.—The committee has continued the study of impact testing begun with the Symposium on Impact Testing held at the last annual meeting. A number of laboratories that contributed data in regard to their practice in impact testing had recommended that it is desirable that American standards should be established and that such work should be undertaken by the Society. A Sub-Committee on Impact Testing has accordingly been organized. The committee has called to its aid seven members of the Society as advisers, having requested them to serve as members of the sub-committee, and in addition the several standing committees of the Society interested in impact testing are also represented. The personnel of the sub-committee is as follows:

E. B. Smith, chairman
R. E. Hess, secretary

Advisory Members:

E. H. Dix, Jr.
W. H. Fulweiler
F. C. Langenberg
T. D. Lynch
D. J. McAdam, Jr.
E. B. Smith
H. L. Whittemore

Representing Standing Committees:

A-1	T. D. Lynch	C-8	M. C. Booze
A-2	H. E. Smith	C-9	E B. Smith
A-3	G. K. Elliott	D-4	A. N. Johnson
A-7	E. Touceda	D-5	T. D. Lynch
B-2	P. D. Merica	D-7	L. J. Markwardt
C-3	F. B. Lysle	D-9	R. W. Seabury
	T. R. Lawson	D-10	C. A. Plaskett

The sub-committee has held one meeting for organization and has adopted the following tentative statement of policy and procedure:

Standards.—Regarding the preparation and recommendation of standards for impact testing, it is probably the best policy for this sub-committee at the present time to study and compare the present various methods of impact testing (including machines and specimens) as used for the various materials before attempting to disturb or formally adopt any of them. Whatever acceptances or recommendations that might be necessary at present should be in the effort to avoid obstructive delays, with the understanding that further suggestions and standardizations may be expected from this committee.

Studies.—It should be the main effort and purpose of this sub-committee for the next two years, or longer if necessary, to study the physical and mathematical fundamentals of impact forces and their effect.

Papers.—It should also be the immediate purpose of this sub-committee to encourage the presentation of papers before this Society, or elsewhere, on:

The Theory of Fundamentals of Impact,
The Methods of Measurement of Impact,
The Results of Tests,

and criticisms and analyses of American and foreign papers on these subjects. Also, to keep an up-to-date bibliography.

The sub-committee has prepared a list of the standards and tentative standards of the Society in which appear descriptions of methods of making impact tests, and a study of these methods is planned for the coming year. It has been decided to make a further study of existing practice in the notched bar impact tests of metals, including an analysis of the data accumulated through the questionnaire in connection with the Symposium last year.

Effect of Temperature and Relative Humidity upon Physical Properties of Materials.—A suggestion has been made to the committee by F. P. Veitch relating to the need for careful consideration of the effect of humidity and temperature in the testing of certain materials. The committee contemplates suggesting to the standing committees that they advise Committee E-1 as to the present practice in maintaining temperatures and relative humidity in testing and the effect of variations upon the results of tests.

This report has been submitted to letter ballot of the committee with the following result: Advisory Committee, affirmative, 5; negative, 0; not voting, 2; total, 7; Standing Committees, affirmative, 20; negative, 0; not voting, 15; total, 35.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

C. L. WARWICK,
Ex-Officio Secretary.

APPENDIX

SUGGESTED METHODS OF TENSION TESTING OF METALLIC MATERIALS

I. TEST SPECIMENS

1. In recommending the following specimens for use in tension tests it is not intended to exclude entirely the use of other test specimens for special materials or for special forms of material; for example, in tests of tubing and pipe the form of specimen recommended for plate material (Fig. 1) is not suitable to use, and a special form of specimen is specified. It is, however, recommended that wherever it is feasible the specimens here recommended be used.

2. Tension test specimens of wire are of the full-size diameter as drawn, and tension test specimens of rods of ductile metal are often of the full-size diameter as rolled. Tension test specimens of pipe and of tubing are frequently of full size as manufactured, in which case the ends should be plugged with metal plugs which shall not extend within the gage marks.

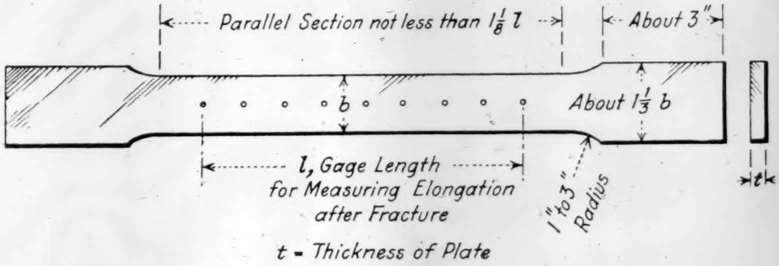

Parallel Section not less than $1\frac{1}{8}l$
About 3"
b
About $1\frac{1}{3}b$
l, Gage Length for Measuring Elongation after Fracture
1" to 3" Radius
t
t - Thickness of Plate

FIG. 1

3. The tension test specimen shown in Fig. 1 is recommended for plate material. The thickness of the specimen is that of the plate material tested. A test specimen with a gage length, *l*, of 8 in. and a width, *b*, of $1\frac{1}{2}$ in. is recommended for general use in testing plate material.

NOTE.—When it is desired to use a specimen with a gage length of less than 8 in., the numerical dimensions of Fig. 1 should be followed. Specimens with a gage length of 2 in. are occasionally used.

For thick plate material, it is usually preferable to use a machined specimen rather than to use a specimen the full thickness of the plate.

Up to the present time it has not been possible to fix a definite line between plate material and sheet material.

4. The tension test specimen shown in Fig. 2 is recommended for general use in testing metals. The gage length for measuring elongation after fracture is 2 in.

5. When it is necessary to cut specimens from material (other than plate material) which is of such size that the specimen shown in Fig. 2 cannot be used, it is recommended that a specimen with dimensions proportional to those shown in Fig. 2 be used and that the specimen be made as large as feasible. In any such small-size specimen it is especially important that the gage length for measuring elongation be four times the diameter of the specimen.

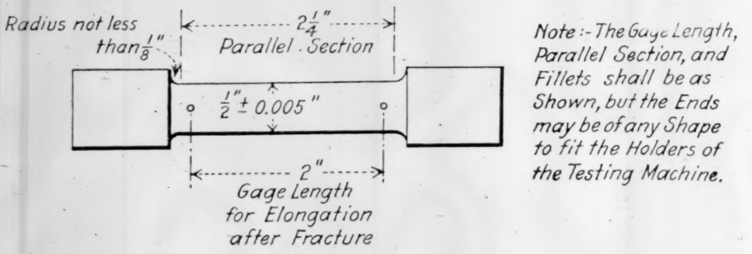
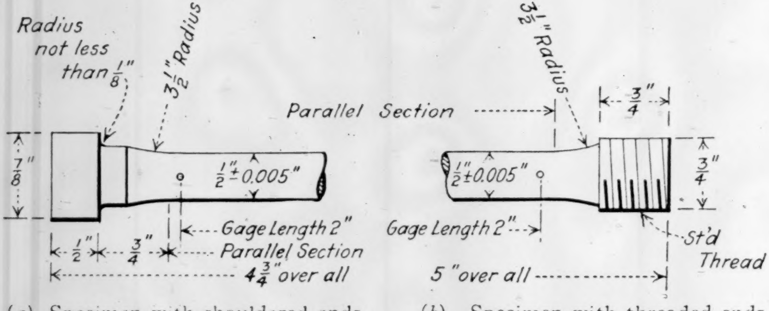

Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.005"
2"
Gage Length for Elongation after Fracture
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine.

FIG. 2.


Radius not less than 1/8"
3 1/2" Radius
7/8"
1/2" ± 0.005"
Gage Length 2"
Parallel Section
1/2"
3/4"
4 3/4" over all
3 1/2" Radius
Parallel Section
3/4"
1/2" ± 0.005"
3/4"
Gage Length 2"
Std Thread
5" over all

(a) Specimen with shouldered ends. (b) Specimen with threaded ends.

FIG. 3.

6. In all tension tests of metals the actual dimensions of cross-section of the test specimens should be measured with a micrometer reading to $\frac{1}{200}$ of the dimension measured, and the stresses should be computed on the basis of the measured cross-section; it should never be assumed that the dimensions of the measured cross-section are identical with the nominal dimensions.

NOTE.—It will be noted that the tolerance for diameter of specimens shown in Fig. 2 permits the use of specimens 0.505 in. in diameter.

7. The shape of the ends of the specimen shown in Fig. 2 are not specified above. For specimens of brittle metal it is especially

important that the diameter of the specimen be changed gradually along its length from the minimum section at the gage length to the diameter at the ends. Fig. 3 shows two forms of end of specimen which have given satisfactory results for tests of brittle metals.[1]

8. Specimens should be finished so that the surfaces are smooth and free from nicks and tool marks. All wire edges should be removed.

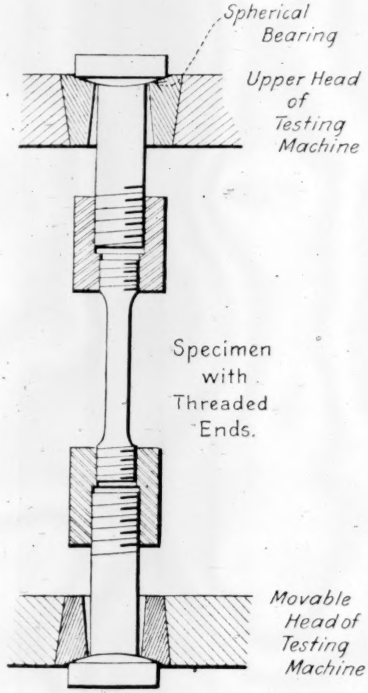

Spherical Bearing
Upper Head of Testing Machine
Specimen with Threaded Ends.
Movable Head of Testing Machine

FIG. 4.

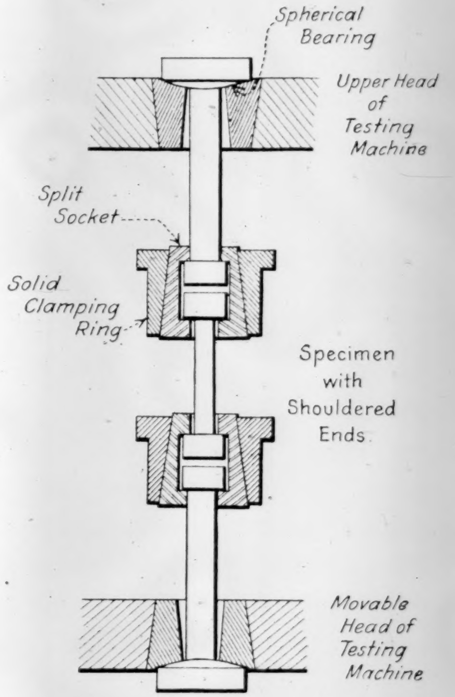

Spherical Bearing
Upper Head of Testing Machine
Split Socket
Solid Clamping Ring
Specimen with Shouldered Ends
Movable Head of Testing Machine

FIG. 5

II. GRIPPING DEVICES FOR TENSION TEST SPECIMENS

9. For long bars of ductile metal and for the flat plate test specimen shown in Fig. 1, wedge grips, bearing directly on the end of the test specimen, generally furnish a satisfactory means of gripping the specimens.

10. For short specimens and for specimens of brittle material, wedge grips are not a satisfactory means of holding test specimens; it is necessary to use machined specimens and to use special means

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[1] Specimens similar to those shown in Fig. 3 have been in extensive use in the laboratories of the British Aircraft Service.

for insuring that the specimen, when under load, shall be as nearly as possible in pure axial tension. Fig. 4 shows a device for gripping tension specimens with threaded ends and Fig. 5 shows a device for gripping specimens with shouldered ends. Both these gripping devices are attached to the heads of the testing machine through spherical-seated bearings. The distance between spherical bearings should be as great as is feasible. For brittle materials, even the spherical-seated bearings shown in Figs. 4 and 5 are not always effective in avoiding bending stress on the specimen. The gripping device shown in Fig. 6 has proved satisfactory for testing such specimens, and is an excellent gripping device for any machined tension test specimen.[1]

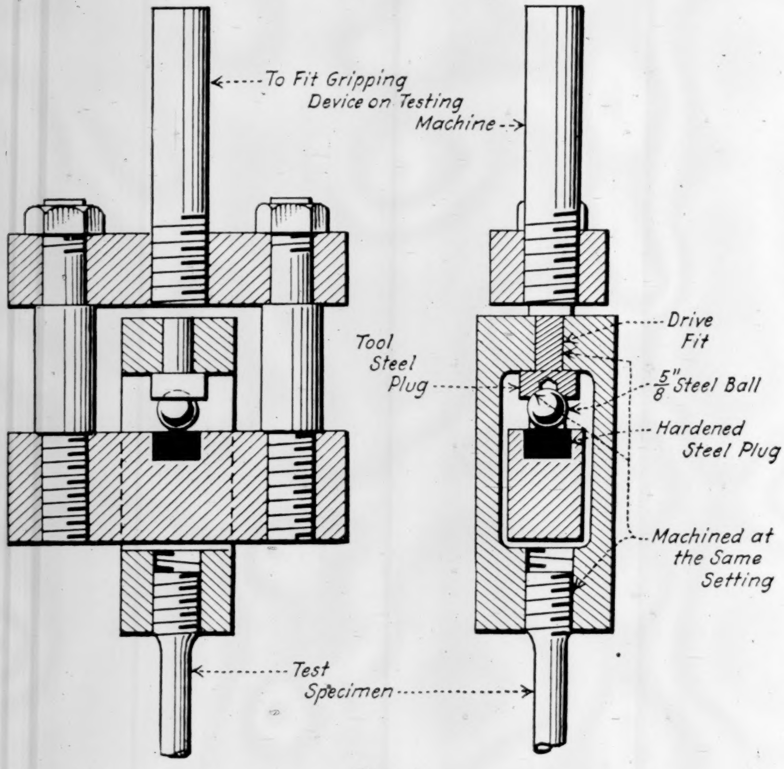
To Fit Gripping Device on Testing Machine
Tool Steel Plug
Drive Fit
$\frac{5}{8}$" Steel Ball
Hardened Steel Plug
Machined at the Same Setting
Test Specimen

FIG. 6

The gripping device is shown as used with threaded end specimens. A similar device fitted with split sockets would be used with shouldered specimens.

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[1] The gripping device shown in Fig. 6 has been extensively used in the laboratories of the British Aircraft Service.

11. For specimens cut from thin plate material and from sheet material, ordinary wedge grips are liable to cut the specimens near the edges, giving a tearing stress rather than an axial tension. The self-adjusting grips shown in Fig. 7 have proved satisfactory for tests of thin sheet copper and aluminum.[1]

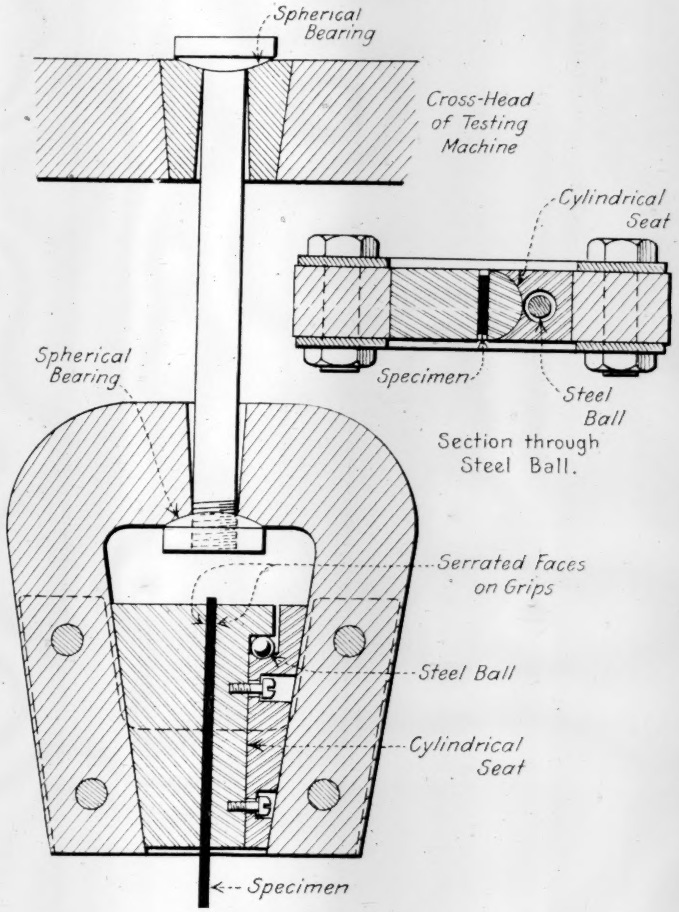
Spherical Bearing
Cross-Head of Testing Machine
Cylindrical Seat
Specimen
Steel Ball
Section through Steel Ball.
Spherical Bearing
Serrated Faces on Grips
Steel Ball
Cylindrical Seat
Specimen

FIG. 7

12. For tests of specimens of wire, ordinary wedge grips are liable to cut the wire at the edges of the grips. This cutting has been found to be largely eliminated by the use of grips of the form shown in Fig. 8.[2]

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[1] The grips shown in Fig. 7 have been extensively used in the laboratories of the Aluminum Company of America.

[2] The grips shown in Fig. 8 have been in extensive use in the Materials Testing Laboratory of the Massachusetts Institute of Technology.

13. In making tension tests, care should be taken to see that the axis of the test specimen is located in the center line of the heads of the testing machine and that the liners used behind wedge grips are of proper thickness. From time to time the openings in the heads of the testing machine should be lined up and the heads tested for parallelism. Deviations from correct allignment and from parallelism should not exceed 0.01 in. The movable head of the machine should be free from sidewise motion which is visible to the unaided eye as the machine is run at its fastest speed.

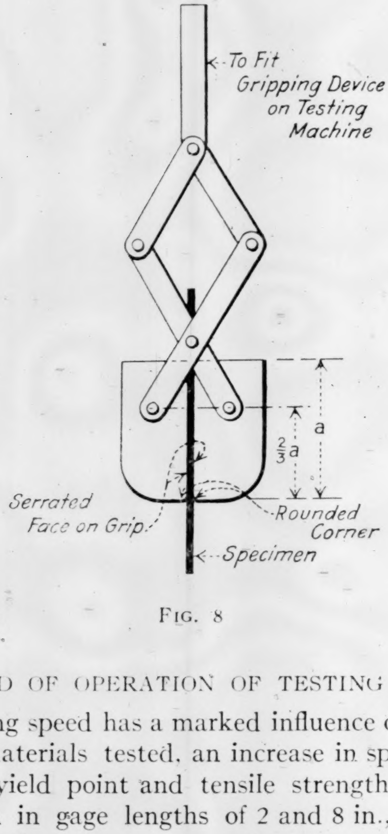

FIG. 8

III. SPEED OF OPERATION OF TESTING MACHINE

14. The pulling speed has a marked influence on the tensile properties shown by materials tested, an increase in speed increasing the values found for yield point and tensile strength. In testing steel and wrought iron in gage lengths of 2 and 8 in., the speed of the machine, by which is meant the speed of the cross-head when the machine is running idle, shall conform to the following requirements:

The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but in no case shall the values given in the following table be exceeded:

Specified Minimum Tensile Strength of Material, lb. per sq. in.	Gage Length, in.	Maximum Cross-head Speed, in. per minute	
		Yield Point	Tensile Strength
80 000 or under	2	0.50	2.0
	8	2.00	6.0
Over 80 000	2	0.25	1.0
	8	0.50	2.0

15. In determining the elastic limit in accordance with Method I, Section 17, the cross-head speed for the 2-in. gage length shall not exceed 0.125 in. per minute.

16. In determining the elastic limit by Method II, Section 17, the cross-head speed shall not exceed 0.025 in. per inch of gage length per minute.

IV. THE DETERMINATION OF ELASTIC LIMIT, YIELD POINT, AND TENSILE STRENGTH

17. The term "elastic limit" is defined as follows:

> *Elastic Limit.*—The greatest stress which a material can withstand without deformation which remains upon release of the load.

The determination of the elastic limit as thus defined would logically involve the application and release of a succession of increasing loads on a test specimen until there was observed deformation after release of a load. This procedure is very slow and since experience does not indicate any appreciable difference between the elastic limit and the limit of proportionality of stress to strain (sometimes called the proportional limit), the determination of the stress at the limit of proportionality of stress to strain is regarded as an accurate determination of the elastic limit.

It is obvious that the values obtained in tests for determining the elastic limit will depend on the delicacy of methods and instruments used. It becomes necessary, therefore, that in any test the method used in obtaining the elastic limit be clearly stated. The following methods are in common use for determining a value designated as the elastic limit:

Method I, proposed by Committee A-1 on Steel, and embodied in a number of specifications for steel. (For tension tests only.) The elastic limit shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer may then be removed from the specimen and the test continued to determine the tensile strength.

Method II (proposed by the late J. B. Johnson) is a somewhat more delicate method for locating the elastic limit than is Method I. In Method II, the elastic limit shall be taken as that stress at which the rate of deformation is 50 per cent greater than the initial rate of deformation. A stress-strain diagram is necessary for determining the elastic limit by Method II. Fig. 9 illustrates the use of Method II. The initial rate of deformation is given by the ratio $mn:Om$. $nq = 0.5\ mn$, $mq = 1.5\ mn$, and the slope of Oq represents a rate of deformation 50 per cent greater than the initial rate. $O'q'$ is drawn parallel to Oq and tangent to the stress-strain diagram. The point of tangency J locates the elastic limit. In using Method II the same precautions should be observed in attaching the strainometer as for the determination of the elastic limit by Method I. Method II, if used for tension tests of metals, gives lower values for the elastic limit than does Method I. It is recommended that in using Method II for tension tests the strainometer be of such sensitiveness that it will indicate a change of unit strain of 0.0001 in. per inch of gage length (0.0001 mm. per millimeter of gage length) and that a corresponding degree of sensitiveness be required for strainometers used for compression tests, for flexure tests, and for torsion tests.

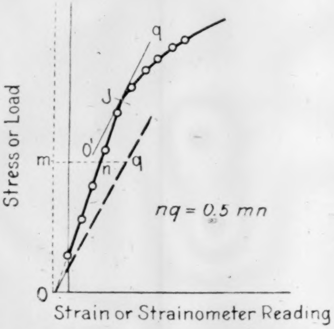

FIG. 9.—Illustrating Method II for Determining Elastic Limit

When it is desired to determine the elastic limit with a high degree of precision, it is suggested that the experimenter devise his own procedure, and in reporting his results describe the procedure in detail, including a statement of the limits of sensitiveness of the apparatus used and of the procedure used in plotting the stress-strain diagram from which the determination of elastic limit is made. It is to be remembered that the accurate determination of the elastic limit requires the use of accurate and sensitive instruments and the use of accurate methods of plotting test data.

18. The term "yield point" is defined as follows:

Yield Point.—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

Two methods are in use for determing the yield point: (I) The "drop of the beam" method, and (II) the method by use of dividers. In Method I, load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at a steady rate. At the yield point the increase of load stops, but the operator, running out the poise at a steady rate, runs it a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device there is a sudden halt of the load-indicating pointer, corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding stress is taken as the yield point. This method of determining the yield point requires only one man to conduct a test.

In Method II for determining the yield point, one observer keeps the beam of the testing machine balanced, and another observer with a pair of dividers watches for visible elongation between two gage marks on the specimen. When visible stretch is observed the fact is at once reported to the man operating the beam of the testing machine, the load at that instant is noted, and the stress corresponding to the load is taken as the yield point. When a strainometer[1] is used in place of dividers a deformation of 0.01 in. over a gage length of 2 in. shall be regarded as indicating the yield point.

Some metals do not have a well-defined yield point.

19. The term "tensile strength" is defined as follows:

Tensile Strength or *Ultimate Tensile Strength.*—The maximum stress carried by a test specimen in a tension test to rupture.

No detailed discussion of methods of determining tensile strength is necessary, as there is involved merely the observing and the recording of the maximum load carried by the specimen during the test.

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[1] The determination of yield point with a strainometer is sometimes made in tests on non-ferrous metals.

V. THE MEASUREMENT, AFTER FRACTURE, OF THE ELONGATION AND THE REDUCTION OF CROSS-SECTION OF TENSION TEST SPECIMENS

20. The measurement of the elongation after fracture of tension test specimens can be made with sufficient accuracy by means of a pair of dividers and a scale. The elongation should not be reported for any tension test specimen which breaks outside the middle third of the gage length.

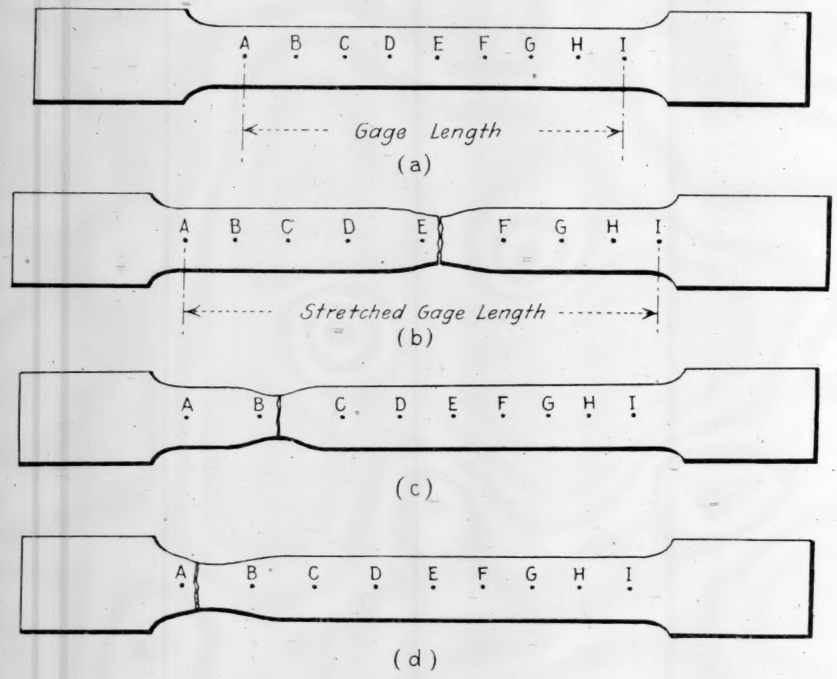

FIG 10

NOTE.—If only a few specimens are furnished for testing it is recommended that in marking the gage length for measuring elongation after fracture it be divided into eight parts, and that if a specimen breaks inside the gage length but outside the middle third of the gage length the requirement in the foregoing paragraph be waived, and the elongation be measured and reported as follows:[1]

(1) If the specimen breaks in the middle half of the gage length (between C and G, Figs. 10 (*a*) and (*b*)) the elongation is measured directly over the stretched gage length (Fig. 10 (*b*)).

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[1] This method is based on suggestions from H. E. Smith, Engineer of Tests, New York Central Lines, and from R. S. Johnston, Engineer Physicist, U. S. Bureau of Standards.

(2) If the specimen breaks between *A* and *C* (or between *G* and *I*) but nearer *B* than *A* (or nearer *H* than *I*, as shown in Fig. 10 (*c*) the elongation from *A* to *C* (or from *G* to *I*) is measured, and to this is added *twice* the measured elongation from *C* to *F* (or from *D* to *G*).

(3) If the specimen breaks within one-half a division of an end gage mark (see Fig. 10 (*d*)) the elongation from *A* to *E* (or from *E* to *I*) is measured and multiplied by 2.

21. The measurement of reduction of the dimensions of the cross-section of a tension test specimen may be made by the direct measurement with a micrometer of the smallest section of the fractured specimen. For round specimens this measurement can usually best be made by holding the broken pieces together in a vise or between centers and then measuring the average diameter of the smallest cross-section by means of a micrometer fitted with points so shaped that they will come in contact with the specimen at its smallest diameter.

VI. PLOTTING STRESS-STRAIN DIAGRAMS

22. A stress-strain diagram is a diagram plotted with values of stress as ordinates and values of strain as abscissas.

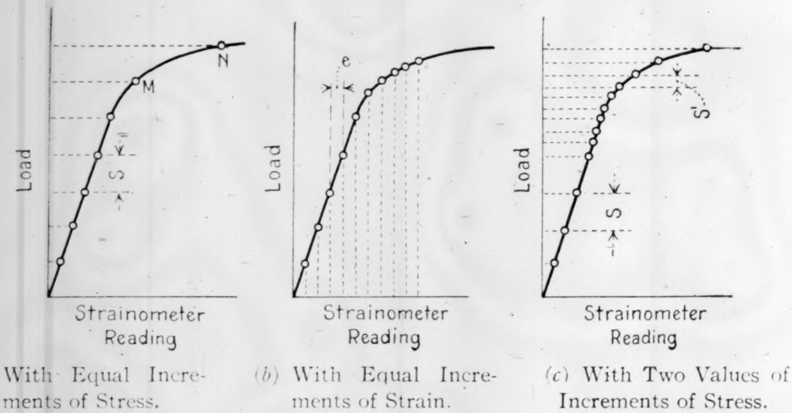
NOTE.—The use of the term "stress-strain diagram" is frequently extended to cover diagrams plotted with values of applied load, or applied moment as ordinates, and with values of stretch, compression, deflection, or twist as abscissas.

Stress-strain diagrams are in some cases drawn directly by an autographic attachment to the testing machine. A more usual method of procedure consists in taking a series of load readings (from the balanced scale beam of the testing machine) with corresponding readings of the strain-indicating apparatus (extensometer, compressometer, deflectometer, or torsion indicator). The term "strainometer reading" will be used to denote the reading of any strain-measuring instrument. From these readings, or from values computed from them, there is plotted a diagram with stress-indicating values (load, flexural moment, twisting moment, or stress) as ordinates, and strain-indicating values (elongation, shortening, deflection, twist, or strain) as abscissas. In planning such a test it is necessary to decide on the increment of load or the increment of reading of strainometer to be used between successive readings.

In Fig. 11 are shown three typical stress-strain diagrams. The material for all three tests is the same, and the test specimens are all of the same size, so that the diagrams should be the same. The diagram shown in Fig. 11 (*a*) is plotted from points determined by taking increments of load (*S*). In this diagram it is seen that owing to the shape of the curve, data for locating points between *M* and *N* are lacking. That particular portion of the curve (the "knee" of the curve) is the part for which it is especially desirable to locate several points on the diagram.

In Fig. 11 (*b*) is shown a diagram plotted from points determined by taking increments of strainometer reading (*e*). It will be noted that for this diagram there are located several points near the knee of the curve, and the shape of the diagram in this important region is much more definitely determined than for the curve shown in Fig. 11 (*a*).

The custom of choosing increments of load rather than increments of strainometer reading is quite common in tests of materials and is followed because, in general, it is easier to compute increments of load than it is to compute increments of strainometer reading. An estimate of the load necessary to stress the specimen up to the knee of the curve is made and some fraction (frequently one-tenth) of this value is taken as an increment. The computation of the corresponding increment of strainometer reading is more complicated.



(*a*) With Equal Increments of Stress. (*b*) With Equal Increments of Strain. (*c*) With Two Values of Increments of Stress.

FIG. 11.—Illustrating Three Methods of Plotting Load-Deformation Curves

Sometimes the practice is followed of applying a few increments of load as determined above, and then applying load in much smaller increments (*S'*) until the knee of the curve is passed. Fig. 11 (*c*) shows a diagram obtained in this manner. This method involves a marked increase in the number of readings necessary for a test and with unknown material there is always some danger that the knee of the curve will be reached before the use of small increments of load is begun.

The following method of choosing increments for a test is suggested: Estimate the load corresponding to the knee of the stress-strain diagram and choose a value for increment of load about one-tenth of this value. Apply this increment of load (*S*) once and note the corresponding change of reading for the strainometer (*e*). Then for the remainder of the test, use for the increment of strainometer reading a value which corresponds to some convenient interval on the scale of the strainometer, and which is approximately equal to (*e*).

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Mechanical Testing of Metallographic Materials were accepted for publication as tentative as two new tentative standards, entitled "Tentative Methods of Verification of Testing Machines," and "Tentative Definitions of Terms Relating to Methods of Testing," appearing on pages 911 and 937, respectively.

DISCUSSION

Mr. Tour

MR. SAM TOUR[1] (*presented in written form*).—Last year, in connection with the proposed tentative methods of verification of testing machines, I called attention to the fact that it is rather difficult to get eight test specimens to give results within ± 1 per cent. This year, I am still of that opinion. It must be realized that this method is going to be used in numerous establishments under widely varying conditions, in many cases by men who operate the machines infrequently and are therefore not highly skilled. An unskilled nontechnical employee cannot be expected to get as uniform results on a series of test bars as does an expert operator. The specification as written is for the verification of the testing machine and not of the system "testing machine plus operator."

In Section 12 (*b*) is specified a crosshead speed of 0.50 in. per minute for test bars with 2-in. gage length and in the note is the statement that a speed of 0.10 in. per minute would be still better, but would make the verification process a very slow one. In order to obtain the uniform results specified, it is quite necessary that a slow rate be used. The time consumed in actual testing will, even with a speed of 0.05 in. per minute, be comparatively brief compared to time required to prepare specimens. In many plants, the making up of a series of test bars of the nature specified will be quite costly and time consuming, and then in a large percentage of cases the work will have to be repeated due to the bars not meeting the uniformity requirement.

The committee proposes that the testing machine used for verifying other machines shall itself be twice verified and that the differences in indications found in the two tests shall not exceed 0.25 per cent. Surely they do not hope to obtain such accuracy with the comparison bar method. Then what method is to be used?

Attention this year is again called to the requirement in Section 15, that "the indicated load of a testing machine shall not be corrected either by computation or by the use of a calibration diagram to obtain values within the required tolerance." Such a requirement is not practical, in my opinion. In many cases during the recent war, testing machines were used which had errors of 3 and 4 per cent, and proper correction factors were used. The proposed requirements

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[1] Metallurgist, Doehler Die Casting Co., Brooklyn, N. Y.

Mr. Tour

would prevent this. In case of another such emergency, we will have to discard any such requirements. To be sure, a machine that is out 3 or 4 per cent can often be corrected by changing the weight of the poise, but if this is done, then the whole calibration must necessarily be repeated. This is an expensive procedure and a time-consuming one.

Further, in regard to tolerances, I see no reason why new machines should be required to be more accurate than used ones. The methods are not for the purchase of machines, but for the use of them to determine certain properties of material. Whether a new or a used machine is used for the purpose, the same accuracy of determination is desired.

Last year, Mr. Moore stated that the calibration-bar method was put aside only temporarily, yet this year the methods are proposed for tentative acceptance and still the calibration-bar method is put aside or shelved. The calibration-bar method is one which depends solely on the elastic property of the material of which the bar is made. As ordinarily used, a special bar of steel is stressed below its elastic limit and its deformation noted by means of a proper measuring device. The apparatus when once made can be used repeatedly and the procedure becomes quite easy of application. There is no question but that many years' use has shown this method to be quick, cheap, accurate, and reliable. Certainly it is as accurate as the comparison-bar method. When the committee allows the use of "machines in which the load-indicating device is actuated by a Bourdon pressure tube, a hydraulic (or steam-engine) indicator spring, or other device depending on the elastic properties of a material" as it does in the note under Section 2, it commits itself to the principle of the calibration bar and calibration-box methods. The methods should therefore be allowed and should be properly classed as more accurate than the comparison-bar method. The following is quoted from a communication of June 6, 1923, received from Mr. Moore: "So far, experience in this country and at the British National Physical Laboratory is not altogether favorable to the use of an elastic bar as a 'high-grade' standardizing apparatus. I hope that there may in the near future be a real tryout of the Amsler calibrating box. We have one at the University of Illinois but have not been convinced that a 100,000-lb. box is accurate within 0.5 per cent within a range of from 10,000 to 100,000 lb. Some experiments recently carried out on various sizes of specimens do seem to indicate that the comparison-bar method of calibrating may be relied on within ± 1 per cent." If we are satisfied with an accuracy of 1 per cent with the troublesome

Mr. Tour comparison-bar method, why should we demand an accuracy of 0.5 per cent in the quicker, cheaper, easier calibration bar or calibration-box method?

Referring now to the proposed tentative definitions of terms relating to methods of testing: "Elastic limit" is defined as "the greatest stress which a material can withstand without deformation which remains upon release of the load." None of the methods of testing suggested is even an attempt at such a determination. To determine the elastic limit in accordance with this definition, some form of "set" method is required. In such a method, the load is released after each added increment and a reading taken on an extensometer or strainometer to determine whether or not permanent deformation has resulted.

Method I, given apparently as an approved method for determining "a value designated as the elastic limit," is really only a fairly accurate method of determining the "yield point." The method states "the observer shall . . . note the load at which the rate of elongation shows a sudden increase." In practice in the ordinary works laboratory the reading, under these instructions, is not taken when the needle or hand of the indicator on the extensometer begins to move a little faster, but it is usually taken when the needle "spins." In a large percentage of cases, this "spin" takes place so rapidly that it is represented by practically no increase in stress. "Yield point" is defined as "the stress in a material at which there occurs a marked increase in strain without an increase in stress." Are the stress being determined by Method I and the stress defined as "yield point" not one and the same stress?

To determine the limit of proportionality of stress to strain in accordance with the definitions proposed, a method must be used which allows of taking strainometer readings after the addition of each increment of load, and of plotting a stress-strain curve and the picking of the value from this curve. Whether the method proposed by J. B. Johnson or some other method is used in selecting the value from the curve, is a separate and distinct question which has to do not with the method of testing, but with the accuracy and sensitivity of the testing machine and strainometer used and the increment between readings.

The committee has not hesitated to propose a change in the basic definitions as to stress and strain, but it has not grasped the opportunity to correct this important defect in our testing procedure, this contradiction between methods and requirements. If a certain elastic limit or proportional limit is desired, then by all means specify it, but

Mr. Tour

under no conditions specify an elastic limit in one breath and in the next breath give a method of determination which cannot possibly determine that which is specified. The "Proposed Tentative Definitions of Terms Relating to Testing" and the methods of testing given in the notes under same do just this and so are not consistent.

Method I was devised by Committee A-1 on Steel. Suppose it insists that it is a reliable method of wide usefulness? Does this mean that the Sub-Committee of Committee E-1 on Mechanical Testing should falter in its duty? Why not come out clearly and say "either you must change your definition of elastic limit or must change your method of determining it or must in the future call the property you are determining by some other name"?

Mr. Comstock, in his discussion of the report of Committee E-1 last year,[1] attempted to bring out this fact that Method I was a "yield point" determination. Mr. Moore, in his answer to Mr. Comstock, missed this point entirely. It is hoped that the sub-committee by diligent search will find other methods than Method I and Method II which can readily be reduced to standardized form and will not be contradictory to their basic definitions.

With reference to the suggested methods of tension testing of metallic materials: In Section 3 the test specimen recommended for plate material has thickness t equal to thickness of plate, a width b of 1.5 in. and a gage length of 8 in. Will the committee please give its reasons for recommending this specimen universally for plate? It is suggested that the committee recommend some definite specimen for all plate above a set thickness, say, 0.625 or 0.75 in., and a set relation between t, b and l for specimens from plates thinner than this. The writer suggests the advisability of considering tests of plate material separate from tests of sheet material. A thickness of 0.15 in. or thereabouts might be considered as the dividing line. It is believed that the matter of test specimens from sheet and plate materials has not been properly taken care of in the methods so far suggested by the committee.

Mr. Schmitt

Mr. F. E. Schmitt.[2]—I should like to ask whether any serious harm will result if these recommendations are not adopted but are simply published without adoption. It seems to me that some of the comments made are serious enough to warrant careful reconsideration before the adoption of the methods and definitions. Personally I have an objection of another kind. The adoption of the definition for stresses as unit stresses is not necessary to any of the work of the

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 528 (1922).

[2] *Engineering News-Record*, New York City.

Mr. Schmitt Society and flies in the face of current practice in structural engineering. I know of no one that will be satisfied to have to use the word "force" as designating the total stress in a member. Why we should be compelled to reserve the term "stress" for stress intensity or unit stress is not apparent. I cannot see that the work of the Society will suffer if that definition is allowed to rest and the matter considered further. The same thing applies to the methods of testing.

The Secretary-Treasurer THE SECRETARY-TREASURER.—I am not sure that Mr. Schmitt understands the recommendation of Committee E-1 with respect to these methods and definitions, which is not that they be adopted as standard but published as tentative in order to bring out criticism and discussion during the year. They were first suggested a year ago and printed in the *Proceedings* as information. A number of criticisms were carefully considered by the committee and certain changes made, and the committee now believes that they may safely be accepted by the Society for publication as tentative. Their inclusion among the tentative standards for the coming year will bring them into greater prominence and the committee will benefit by the criticism and discussion that they will receive.

Mr. Lynch MR. T. D. LYNCH.[1]—As a representative of Committee A-1 on Steel on Committee E-1, I should like to discuss the point Mr. Tour referred to respecting Method I for determining elastic limit. That method was discussed fully in Committee A-1 when it was first proposed, and it was adopted because the committee had nothing better at that time. The committee has built certain of its specifications around it and if Committee E-1 should change it or omit it, these specifications would no doubt be affected. It was on that account I favored the adoption of this method as tentative, at least for the present, so that if another method is adopted Committee A-1 could, if it so decided, modify the specifications as needed.

Mr. Talbot MR. ARTHUR N. TALBOT.[2]—I can not help referring to the definitions of "stress" and "strain" reported by the committee. It seems to me unfortunate that the Society should adopt them. The definitions proposed are highly specialized definitions of the two words. This use may be proper for the physicist, dealing with certain limited conditions, and not needing to go into applications. The Society is connected closely with the engineer, and surely the engineer has the right to continue the use of "stress" and "strain," those good old Anglo-Saxon terms, as meaning something besides intensity of stress and strain. As someone mentioned this morning, this limiting of the use of the words will be raising an issue with the engineer. We should be on much better terms with the engineer, who is dealing with stress and strain so intimately, if we recognized that the more general meaning of the term, as used by the engineer, is proper, and that the one proposed by the committee is a specialized use suited for certain purposes only. **Mr. Talbot**

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[1] Acting Manager, Material and Process Engineering Department, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

[2] Professor of Municipal and Sanitary Engineering, and In Charge of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill.

MR. L. B. TUCKERMAN.[1]—I merely want to comment on one point. The words "stress" and "strain" are not used in that sense by the engineering profession throughout the world; the usage is quite varied. One English engineer uses "stress" in the sense of force and intensity of stress for force per unit area; then another English engineer will use stress in the physicist's sense. The word "strain" in England is used in the sense of deformation per unit of length. Deformation is used where the American engineer uses strain. Foreign languages have adopted definitions practically the same as those proposed by Committee E-1. **Mr. Tuckerman**

The question whether we should specialize the meaning of words is a matter of policy. We have had to do it. I have in my library a very interesting old book which speaks about the conservation and correlation of physical forces, and I know people to-day who insist that they have a right to use the good old Anglo-Saxon word "force" to mean kinetic energy, stress, strain, or anything else; but to-day we agree that it is necessary to specialize and mean a particular thing by "force." I do not know that the time has come or not when we should specialize in the use of the words "stress" and "strain." If it has, the specialization should be made consistent throughout the scientific world.

MR. H. F. MOORE[2] (*Chairman, Sub-Committee on Mechanical Testing, closure by letter*).—The writer is glad that this report had such vigorous discussion on the floor of the meeting and regrets that the available time did not allow even fuller discussion. **Mr. Moore**

The criticisms of the report fall under several heads. There has been criticism by engineers on the action of the committee in following the physicist's definitions for stress and strain. Last year in its report the committee submitted the engineer's definitions of stress and strain. Several physicists present vigorously attacked these definitions, and no voice was raised in their defense by the engineers present. In view of that state of affairs it is not surprising that the committee felt that the preponderance of opinion favored the

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[1] Engineer Physicist, U. S. Bureau of Standards, Washington, D. C.

[2] Professor of Engineering Materials, University of Illinois, Urbana, Ill.

Mr. Moore physicist's definitions: this year engineers objected to the physicist's definitions, and the physicists present offered no defense. There are in use two well-recognized sets of definitions of stress and strain: the physicist's definitions and the engineer's definitions. The committee has chosen the one of them which so far seems most serviceable.

The other points which have been discussed have practically all been included in the vigorous discussion submitted by Mr. Tour, and the writer will comment on these points as they are presented in Mr. Tour's discussion.

In connection with the calibration of testing machines, Mr. Tour points out that unskilled, non-technical employees cannot be expected to get highly uniform results on companion test bars used for calibrating machines. He might have added that, with *no* method can a non-skilled non-technical employee be expected to carry out an accurate calibration of a testing machine. Under any conditions calibration must be done by skilled men.

The companion-bar method is in actual use in a number of places. The committee felt that it was better to standardize, so far as possible, this existing, fairly satisfactory method for calibrating testing machines rather than ignore it.

The question is raised that the testing machine used for verifying other machines must also be twice verified, and the two verifications must agree within narrow limits, and the question is asked "what method is to be used in verifying this standard machine?" The answer is that the dead weight method or the proving lever method would probably be used for the standard machine.

The recommendation that the use of a calibration diagram to bring indicated values of a testing machine within the required tolerance be not allowed is a result of many years experience with weighing scales. The practice of standardization of weighing scales is much further advanced than is the practice of standardization of testing machines, and the committee has, in general, followed calibration practice for weighing scales where it seemed applicable to the case of testing machines. If a testing machine is in error beyond the allowed tolerance, the calibration would have to be repeated throughout the entire range to obtain a calibration diagram. It would entail very little, if any, additional work to change the weight of the poise to make the readings of the testing machine come within the tolerance.

The criticism that new machines should not be required to be more accurate than used machines is an interesting one. Here again the committee has followed practice used in the standardization of weighing scales. This point should, however, be discussed further

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by the committee before the tentative standards are submitted for final approval.

The committee has been criticized for "shelving" the "calibration-bar" methods of standardizing testing machines. Again I would point out that this method is by no means abandoned. As a matter of fact from very recent tests at the U. S. Bureau of Standards and at the University of Illinois, it may now be possible to formulate standards for such a standard bar. If a standard bar is of sufficient capacity for the full load of the testing machine, it is apt to be lacking in precision for the lower loads of the machine. This, of course, might be obviated by using two or more standard bars, but at the time this report was formulated the committee could *not* agree with the statement in Mr. Tour's discussion "there is no question but that many years' use has shown this method [the standard bar] to be quick, cheap, accurate, and reliable." The committee could find in existence no really reliable data as to the accuracy of this method. It may be noted that the old standard methods of testing of this Society did give specifications for such a standard bar. The writer knows of at least one case of a large testing machine for which it was found that a standard bar could not be constructed and calibrated as required by the old specifications of the Society.

Mr. Tour quotes from a letter to the effect that a calibration bar is required to be accurate within 0.5 per cent within a range from $\frac{1}{10}$ load to full load, while Mr. Tour stated that a tolerance ±1 per cent is allowed in the comparison-bar method.

There is no requirement for accuracy of calibration bar in the committee's report, nor in the suggested tentative standards; moreover, for the companion-bar method of calibration the requirement is that *no individual specimen* shall be considered for which values vary from the mean by more than ±1 per cent. This requirement would, in general, bring the *error of the mean value* for three or four specimens within 0.5 per cent.

Perhaps the most vigorous discussion of the committee's report is in connection with the proposed methods of determining elastic limit. In presenting proposed standard methods the committee attempted to recognize and standardize existing methods which had given good results in service. Committee E-1 is composed of representatives of the other committees of the Society; it is *not* a super-committee, sitting as a supreme court of testing methods, but is rather a service committee, attempting to correlate the standard methods of testing developed in the other committees, and offering its services to committees contemplating the codification of methods

Mr. Moore of testing for new materials. The writer wishes to object vigorously to the insinuation that in recognizing current practice and terminology and successful test methods, the committee has in any sense "faltered in its duty."

In connection with Method I for determining elastic limit, Mr. Tour claims that this method is, in effect, the same as that used in determining yield point. The writer cannot agree to this claim. The yield point is defined as "the stress at which there occurs a marked increase in strain *without an increase in stress.* The limit determined by Method I determines, in general, a limit at which *stress is still increasing.* In general, yield point as determined by the drop of the beam is found at a stress distinctly higher than the value determined by Method I. The writer wishes to state very emphatically that, in his judgment, the limit determined by Method I and the yield point are *not* "one and the same stress." Reference has been made to the discussion submitted last year by Mr. Comstock. Mr. Comstock did not claim that Method I was identical with the method commonly used in determining yield point, but that Method I was an inaccurate and indefinite method, not more accurate nor more definite than the methods commonly used for determining yield point. He stated that, in his opinion, the term "yield point" better fitted the value determined by Method I than did "elastic limit." At that time the writer answered him by stating that Method I for determining elastic limit had been in successful use by the Society for several years.

There seems to be a feeling that any method for determining elastic limit must be applicable to all materials. In the writer's opinion this is not necessarily true. In chemical determinations, different methods for determining the amount of a given ingredient vary for different substances analyzed. It seems quite reasonable that for certain ductile steels, Method I would be a very serviceable method of determining elastic limit, that for certain non-ferrous metals Method II would be better, and that for certain very hard steels some still more delicate method would be necessary.

The criticism that the methods are not logical does not seem to the writer to have much weight. We determine weight by platform scales, notwithstanding that logically we determine not weight (earth-pull) but "mass." Practically the platform scale is a better weight measurer than its logical superior the spring balance. It is true that Method I and Method II for determining elastic limit do not measure directly "the greatest stress which it (the metal) can withstand without deformation which remains upon release of the load," but they do determine with fair accuracy the limit of propor-

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tionality of stress to strain, which experience has shown is, for nearly all structural metals, practically the same as the limit of permanent set after load, though in the case of some of the newer materials, such as the aluminum alloys, this statement may have to be revised. Method I is a method for determining, rather roughly it is true, a limit at which the rate of stress with respect to strain increases noticeably, and hence this method may be regarded as a somewhat rough method of determining the limit of proportionality. The writer would wish to express his dissent from the statement that this method of determination "cannot possibly determine that which is specified," unless there is taken the viewpoint that the elastic limit is some definitely fixed value, which viewpoint is certainly not justified by experience. Again the writer wishes to register his protest against the insinuation that in recognizing this widely used method for determining a value called the elastic limit, Committee E-1 has in any sense "faltered in its duty." This is not a moral question, but one of technical procedure.

The committee, as Mr. Tour suggests, should undoubtedly be in a receptive mood to other methods for determining elastic limit. Specifically it is the writer's opinion that they should strive to formulate a third method for determining elastic limit based on the existence of some definite amount of "set" after a given "proof stress."

The question of standard specimens for plate and for sheet materials is not by any means a closed issue. Mr. Tour asks the committee to give its reasons for recommending a specimen with a width of 1.5 in. and a gage length of 8 in. "universally for plate." A reading of the committee's report will show that the committee did no such thing, but that it recommended a general form of specimen for plate and stated that the specimen with dimensions given above, was recommended for *general* use in plate material. In a note the committee specifically recognized the use of test specimens with other than 8-in. gage lengths.

Mr. Tour suggests that the question of test specimens for sheet material is a separate one from the question of test specimens for plate materials. His suggestion is a good one. The representatives of various committees have not so far been able to recommend standard test specimens for sheet material, nor have they made any specific recommendation as to the dividing line between plate material and sheet material. If Mr. Tour, by his statement that the matter of test specimens from sheet and from plate material has not been properly taken care of, means that further revision will be necessary, the writer is in hearty agreement with him.

Mr. Moore In conclusion, may the writer again state that he is glad that the report has had such vigorous discussion and that the only portion of the criticism toward which he feels resentment are the insinuations that inability on the part of the committee to present at this date a finished outline of methods of tension tests, and the policy of the committee of recognizing standard methods developed by the other committees of the Society should be construed as a failure to perform duty. The proposed definitions and methods are neither complete nor final. It is very improbable, and in the writer's opinion very undesirable, that standard methods of testing shall ever be permanently fixed. The methods proposed represent in most cases an attempt at correlating existing methods of testing in successful use by various committees of the Society. In presenting such methods the writer believes that the committee is performing its duty.

REPORT OF COMMITTEE E-4
ON
METALLOGRAPHY

During the year, Committee E-4 held three meetings: One in Atlantic City on June 28, 1922, one in Philadelphia on October 28, 1922, and one in New York City on April 23, 1923.

There have been several accessions to membership. The committee now consists of 41 members.

One new sub-committee has been appointed during the year, Sub-Committee V on Micro-Hardness. All of the sub-committees are now fully organized and working to good advantage.

The committee offers proposed Tentative Methods for Metallographic Testing of Non-Ferrous Metals and Alloys, and recommends that they be accepted for publication as tentative. These proposed methods are appended to this report.[1]

The committee offers a proposed Tentative Recommended Practice for Photography as Applied to Metallography,[2] and recommends that it be published as tentative. This may possibly later be recommended for consolidation with the Standard Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2 - 20), but before making such recommendation the committee feels that it should be published as tentative.

Committee E-4 has made progress in the matter of thermal analysis. A preliminary report on this subject has been prepared by Messrs. Harder and Phillips. A questionnaire has been sent out to various individuals and laboratories who were interested in the subject and a very good response has been received. It is hoped that still more replies may be secured to this questionnaire. The data obtained are valuable and the committee hopes to have this in condition for a complete report at the next annual meeting of the Society.

Messrs. Harder and Phillips have also prepared a bibliography of Thermal Analysis and Pyrometry which will also become a part of the proposed report.

The Sub-Committee on Micro-Hardness is making a study of methods for obtaining the "scratch" or "scoring" hardness, making use of the instruments recently described by C. H. Bierbaum[3] for this purpose. Specimens have been prepared and are being distributed among the members for the checking of instruments and the standardizing of methods.

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[1] See p. 931.—Ed. [2] See p. 945.—Ed.

[3] C. H. Bierbaum, "A Study of Bearing Metals," Am. Inst. Mining and Metallurgical Engrs., February meeting, 1923.

The committee offers for publication a paper on "The Identification of Non-Metallic Inclusions in Iron and Steel" by William Campbell and George F. Comstock.

The committee offers the proposed revised Tentative Definitions of Terms Relating to Metallography, appended hereto,[1] as a revision of the Tentative Definitions (E 2 – 21 T)[2] and recommends that they be accepted for publication as tentative.

The committee recommends the following revisions in the Tentative Methods of Metallographic Testing of Iron and Steel (E 3 – 21 T):[3]

Add a new Section 4 under Solutions Used in Etching, in Macroscopic Examination, to read as follows, re-numbering the subsequent section accordingly:

> "For etch tests to distinguish between wrought iron and steel, to develop the structure of welds, etc., the following rapidly acting reagents are recommended:

(*a*)	Hydrochloric acid (sp. gr. 1.19)............	10 per cent
	Sulfuric acid (sp. gr. 1.84)................	30 "
	Water..................................	60 "
(*b*)	Nitric acid (sp. gr. 1.42).................	25 per cent
	Water..................................	75 "

The committee recommends that the methods, as revised, be continued as tentative.

This report has been submitted to letter ballot of the committee, which consists of 41 members, of whom 38 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. H. BASSETT,
Chairman.

G. F. COMSTOCK,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Methods of Metallographic Testing of Iron and Steel; and of the Tentative Definitions of Terms Relating to Metallography, referred to in this report, were accepted. The tentative standards as thus revised appear on pages 919 and 943, respectively.

The proposed Tentative Methods of Metallographic Testing of Non-Ferrous Metals and Alloys; and the proposed Tentative Recommended Practice for Photography as Applied to Metallography referred to in this report were accepted for publication as tentative and appear on pages 931 and 945, respectively.

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[1] See p. 943.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 829 (1921).

[3] *Ibid.*, p. 817.

APPENDIX

IDENTIFICATION OF NON-METALLIC INCLUSIONS IN IRON AND STEEL

By William Campbell and G. F. Comstock

In the Tentative Methods of Metallographic Testing of Iron and Steel (E 3 – 21 T),[1] presented by Committee E-4 on Metallography in 1921, the chief methods for identification of non-metallic inclusions were given. An attempt was then made to give in tabular form the various means of distinguishing these different inclusions.

In actual work, while it is often comparatively easy to identify the larger and more characteristic inclusions such as typical manganese sulfide, iron silicate, oxide, sand grains, there are always some inclusions whose identity is in doubt. The reason for this is at once evident if we consider the constitution of the various sulfides, oxides, silicates, etc. For example, when we examine a sample of puddle slag or tap cinder, which has been allowed to solidify and cool comparatively slowly, the structure is quite coarse and the different constituents have crystallized out in regular order and can be identified, but when we examine slag inclusions in wrought iron we find, in one and the same section, quite a variety of inclusions varying in structure and apparently in composition from what we consider to be pure oxide to pure silicate. That the silicate is variable in composition there can be little doubt. In steel the variation is probably even greater. Slag inclusions in steel are probably solid solutions of manganese and iron silicates in acid steel, but in basic steel are generally duplex in structure and show grains and sometimes crystals of oxide, etc., surrounded by a matrix of silicate. In the same way manganese sulfide can contain over 50 per cent of iron sulfide in solid solution and its color changes correspondingly. Probably what we generally term "iron oxide" contains more or less manganese oxide in solution.

As these various sulfides, oxides and silicates vary in composition, so will their etching characteristics vary to a greater or less extent, and this must be taken into account in any systematic method of determination.

Since 1921, considerable work has been done on this subject and a number of new methods of etching have been tried or suggested.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 817 (1921).

During the past year, Mr. Comstock has tried out a number of reagents and the accompanying table has been worked out by him with a view to simplify our methods of determination. This table is presented with a view to bringing forth discussion, suggestions and corrections rather than as the final solution to the question. Where two methods equally definite in their results were available the simpler was chosen in order to make the scheme of easy application in routine work, where time is a serious factor. For research work, in contradistinction to routine determinations, the more elaborate and lengthy methods can be used.

DETERMINATION OF INCLUSIONS IN STEEL

Polish carefully with minimum pitting, and project magnified image on ground glass by arc or equally white light, without color screen. Note color.

A. Gray or black inclusions.—

Etch with 10-per-cent nitric acid in alcohol for 10 seconds.

Attacked = lime compound from mold wash.

Unattacked, etch with 10-per-cent chromic acid in water for 5 minutes.

Attacked = Manganese sulfide.

Unattacked, etch in boiling alkaline sodium picrate for 5 minutes.

Attacked = Manganese oxide.

Unattacked, etch in strong boiling KOH for 10 minutes.

Attacked = Manganese silicate.

Unattacked, etch with strong solution of stannous chloride in alcohol for 10 minutes.

Attacked = Iron oxide. (May be checked by electrolytic reduction with nascent hydrogen, when FeO is reduced to metal and other inclusions are either attacked or unchanged.)

Unattacked, etch with fairly strong HF solution (McCance sol. B) 10 minutes.

Attacked = Iron silicate.

Unattacked, repolish and note color and form:

1. Very dark color, fine particles difficult to polish without pitting, not elongated by hot work = Alumina.
2. Color not especially dark, easily polished smooth without pitting:
   - (*a*) Fairly large angular fragments, showing changeable bright spots as focus is changed = Sand grains (in steel castings).
   - (*b*) Small angular particles, bluish in color, without changeable bright spots = Probably titanium oxide (in titanium treated steel).

B. Brown, yellow, red or purple inclusions.—

Etch in strong boiling KOH or alkaline sodium picrate for 10 minutes.

Attacked = Iron sulfide.

Unattacked:

1. Purplish color, rather easily polished smooth = Chromium oxide.
2. Pink color, strongly angular form, rather difficult to polish without pitting = Titanium cyano nitride.
3. Yellow, cubes or cubic forms = Zirconium nitride.

REPORT OF COMMITTEE E-8
ON
NOMENCLATURE AND DEFINITIONS

Committee E-8 has made considerable progress during the year in harmonizing the tentative definitions of terms before it. In accordance with the classification of terms outlined in its report for 1922, it has given consideration to definitions in one of two ways. Those definitions which clearly concern only one standing committee were reviewed by the Editorial Committee of the Advisory Committee and then taken up with the standing committee concerned, suggestions for rewording and clarification of the definitions being offered by the Advisory Committee to the standing committee in question. Those terms which concerned more than one standing committee were referred to suitable sub-committees. The following sub-committees accordingly have been organized:

On Specific Gravity (F. M. Farmer, Chairman).
On Definition of the Term Clay (A. S. Watts, Chairman).
On Definition of the Term Sand (L. R. Ferguson, Chairman).
On Definition of the Terms Loam, Silt, Gravel, and Related Terms (L. R. Ferguson, Chairman).
On Definition of the Terms Sieve and Screen (L. R. Ferguson, Chairman).
On Definition of the Terms Moisture and Ash (H. C. Porter, Chairman).

In addition, a sub-committee for the consideration of Terms Relating to Gypsum has been authorized, but the organization of this sub-committee has not as yet been effected.

While some of these committees have found it desirable to call meetings, for the most part the work has been handled by correspondence. The Advisory Committee of Committee E-8 held a meeting in November and another in March in conjunction with the regular meeting of Committee E-8. It is expected that the Advisory Committee will meet again during the present annual meeting. The regular November meeting of the committee was canceled, and accordingly only one meeting of Committee E-8 was held during the year, that of March 2, 1923.

Committee E-8 has continued its policy of giving consideration to only tentative definitions of terms, believing that its best course would be to dispose of the tentative terms as its immediate work, and after this work was well in hand to turn to the more difficult problem of reviewing the definitions already made standard. As stated in its report for 1922, 133 terms had been given consideration prior to that report. Of these, 13 terms were considered as not being definitions and after communicating with the standing committee concerned, were dropped from further consideration. Three terms, "fine aggregate," "coarse aggregate" and "pipe laying," were referred to the standing committees concerned and their status is still under consideration by those committees. Nine terms relating to paint, and the definition of the A.S.T.M. Paraffin Wax Melting Point were definitely approved and advanced to Standard at the last annual meeting of the Society. Two other terms: namely, "creosote oil," and "Keene's Cement" have been eliminated from the Tentative Standards in which they appeared, and accordingly will be given no further consideration. This would leave 105 terms mentioned in the 1922 report still before Committee E-8.

At the 1922 annual meeting, 28 additional tentative terms, of which two terms, "hydrated lime" and "quicklime," had been submitted in specifications prior to 1922 but were re-submitted as tentative definitions in 1922, were submitted to the Society. The total number of terms before Committee E-8 is accordingly 131.

TENTATIVE DEFINITIONS OF TERMS SUBMITTED PRIOR TO 1922

Of the 105 terms remaining before Committee E-8 after the 1922 annual meeting a number are now being recommended for advancement to standard. Still others are remaining as tentative but have been given the approval of Committee E-8. Still others, those which are in the hands of the sub-committees, will still require considerable work before satisfactory definitions can be reported. The action taken to date on each of the terms is as follows:

Terms Relating to Coke (*D 121*).—The 15 terms defined by Committee D-6 on Coke, whose work has since been taken over by Committee D-5 on Coal and Coke, are as follows:

Coke
Beehive Coke
By-Product Coke
Gas House Coke
Domestic Coke
Foundry Coke from Beehive Ovens
Foundry Coke from By-Product Ovens
Furnace Coke from Beehive Ovens
Furnace Coke from By-Product Ovens
Coke Breeze
Dry Coke
Moisture
Ash
Volatile Matter
Fixed Carbon

The definitions of the terms "moisture," "ash," "volatile matter" and "fixed carbon" with certain revisions suggested by the Editorial Committee have been referred to a representative sub-committee of Committee E-8, under the chairmanship of H. C. Porter. The definitions of the remaining 11 terms, after having been reviewed by the Editorial Committee, were referred by the Advisory Committee to Committee D-5. It is believed that little difficulty will be experienced in having these definitions finally reworded so as to meet the approval of both Committees D-5 and E-8.

Terms Relating to Gypsum (C 11, C 22, C 23, C 36, C 37).—The 15 terms defined by Committee C-11 on Gypsum are:

Accelerator
Aggregate
Binder
Cement
Consistency
Mortar
Plaster
Plasticity
Retarder
Stucco
Wood Fiber
Gypsum
Calcined Gypsum
Gypsum Wall Board
Gypsum Plaster Board

The definitions of the terms "consistency" and "plasticity" are now receiving considerable discussion in a sub-committee of Committee E-1 on Methods of Testing, as a result of which a report is being presented at this annual meeting which will partake of the nature of a Symposium on Consistency with particular reference to cementitious materials. As a result of this Symposium on Consistency, it is hoped that some basis will be arrived at for the formulation of definitions of the terms "consistency" and "plasticity." Rewordings of some of the definitions relating to gypsum have been referred to Committee C-11. The remaining terms come under the jurisdiction of the sub-committee, of Committee E-8, on Gypsum Terms. As previously mentioned, this sub-committee is now in the process of organization. The definition of "aggregate" has been referred to a sub-committee under the chairmanship of L. R. Ferguson, which is now engaged on the preparation of a definition for the term "sand."

Terms Relating to Hollow Tile (C 43).—The 26 terms defined by Committee C-10 on Hollow Building Tile are as follows:

Clay Hollow Tile
Terra Cotta
Hollow Building Tile
Load-Bearing Tile
Floor Tile
Foundation Tile
Side Construction Tile
End Construction Tile
Back-up Tile
Book Tile
Hollow Tile Fireproofing
Partition Tile
Furring Tile
Porous Tile
Vitrified Tile
Salt-Glazed Tile
Shale
Fire Clay
Surface Clay
Thickness
Width
Length
Shells
Webs
Cells
Scoring

The terms included in this group, with the exception of the terms "shale," "surface clay," and "fire clay," seem to concern only the one standing committee having proposed them. After being reviewed by the Advisory Committee and discussed with Committee C-10, the principal change agreed upon was the elimination of the definition for "clay hollow tile" and the insertion in its stead of a definition for the term "hollow tile" with the addition of a note, the definition and note reading as follows:

"*Hollow Tile.*—Hollow building units with parallel cells."

"NOTE.—In the present state of the art the term 'hollow tile,' if used without a qualifying adjective, is generally understood to mean clay hollow tile."

At the suggestion of Committee E-8, Committee C-10 included a definition for the term "split tile." The definitions as revised were submitted to Committee E-8 for approval, the letter ballot vote on this recommendation being as follows: Advisory Committee, 6 affirmative, 0 negative, and 1 not voting, total 7. Standing Committees, 20 affirmative, 2 negative, and 14 not voting, total 36. The definitions are being recommended by Committee C-10 for advancement to standard.[1]

The three terms "shale," "surface clay" and "fire clay" are still under consideration by a sub-committee, of Committee E-8, on Clay, under the chairmanship of A. S. Watts. The work of this sub-committee is treated elsewhere.

Terms Relating to Textiles (D 76, D 122, D 123).—The 16 terms defined by Committee D-13 on Textile Materials are as follows:

Imperfections
Misweaves
Tolerances
Mechanical Fabric
Tire Builder Fabric
Tire Cord Fabric
Hose Duck
Rubber Belt Duck
Balata Belt Duck
Oil Belt Duck
Numbered Duck
Army Duck
Single Filled or Flat Duck
Enameling Duck
Crimp
Off-Square

Revisions in the wording of the majority of these definitions were suggested by the Editorial Committee. These have been referred by the Advisory Committee to Committee D-13, since it was apparent that this standing committee is the only committee concerned. In its annual report for 1923, Committee D-13 is submitting revisions of a number of the terms referred to above, which revisions for the most part follow the lines suggested by Committee E-8. It is expected that Committees E-8 and D-13 will be able to agree on satisfactory definitions during the coming year.

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[1] The recommendation to advance the Tentative Definitions of Terms Relating to Hollow Tile to standards was withdrawn by Committee C-10 at the annual meeting. See Summary of Proceedings, page 32.—ED.

Terms Relating to Timber (*D 23*).—The 10 terms defined by Committee D-7 on Timber are as follows:

Annual Ring
Summer Wood
Dense Douglas Fir
Sound and Tight Knot
Encased Knot
Loose Knot
Rotten Knot
Ring Shake
Round Shake
Diagonal Grain

Revisions as suggested by the Editorial Committee have been referred to Committee D-7 for consideration and Committee D-7 is now reviewing these definitions as a part of a more extended study it is now making of all definitions relating to timber. This subject is treated elsewhere.

Definitions of Terms Relating to Metallography (*E 2*).—The 18 terms defined by Committee E-4 on Metallography are as follows:

Achromatic
Alloy
Alpha Brass
Apochromatic
Etching Reagent
Equi-axed
Grain
Grain Size
Illuminator
Intercept Method for Grain Count
Lens
Achromatic Objectives
Macrograph
Magnification
Metal
Micrograph
Muntz Metal
Planimetric Method for Grain Count

The Advisory Committee, in conference with Committee E-4, has reviewed the several definitions relating to metallography. As a result, Committee E-4 is recommending in its report for 1923 a complete revision of the tentative definitions. A number of terms, not really definitions but formerly included, have been withdrawn on the recommendation of Committee E-8, and the material included in these definitions has been incorporated more appropriately in other standards.

Miscellaneous Terms.—There are 5 terms classified as miscellaneous:

Ductility (D 113)
A.S.T.M. Lubricating Oil Precipitation Number (D 91)
Quicklime (C 5)
Hydrated Lime (C 6)
Specific Gravity (D 70, D 71)

The definition of "ductility" as given by Committee D-4 on Road and Paving Materials, as applying to the ductility of asphalt cement, was referred back to Committee D-4, since it was felt by Committee E-8 that the definition as worded could scarcely be considered a definition of "ductility" but rather a description of how that property is determined. Committee D-4 is giving consideration to a revision of the standard in question. The definitions for the terms "quicklime" and "hydrated lime" were incorporated by Committee C-7 in a separate standard entitled "Definitions of Terms Relating to Lime," which was submitted by Committee C-7 in 1922. They are accordingly discussed below with the definitions presented in 1922.

TENTATIVE DEFINITIONS OF TERMS PRESENTED IN 1922

The definitions of terms, 28 in number, submitted in 1922 are grouped conveniently according to subject matter and the standing committees responsible for them as follows:

	COMMITTEE PROPOSING DEFINITION	NUMBER OF TERMS DEFINED
Terms Relating to Lime (C 51)	C-7	5
" " " Coal (D 141)	D-5	6
" " " Waterproofing Materials (D 146)	D-8	3
" " " Rubber Analysis (D 15)	D-11	4
" " " Textiles (D 123)	D-13	6
Miscellaneous Terms:		
Virgin Lead (B 29)	B-2	1
Petrolatum Melting Point (D 127)	D-2	1
Cloud Point (D 97)	D-2	1
Pour Point (D 97)	D-2	1
		28

Terms Relating to Lime.—The five terms defined by Committee C-7 are as follows:

Quicklime
Hydrated Lime
Lump Lime
Lump Lime Screened
Pulverized Lime

As mentioned above, two of these terms had been submitted by Committee C-7 prior to 1922, the definition for "quicklime" having been contained in the Specifications for Structural Quicklime and the definition of the term "hydrated lime" having been contained in the specifications for that material. In 1922, the two terms were removed from the specifications and with three other terms were submitted as Tentative Definitions of Terms C 51. Committee E-8, believing that Committee C-7 was the only standing committee concerned with these definitions, has referred them back to that committee with a number of suggestions for rewording.

Terms Relating to Coal (D 142).—The six terms presented by Committee D-5 on Coal and Coke are as follows:

Moisture
Ash
Volatile Matter
Fixed Carbon
Proximate Analysis
Ultimate Analysis

The definitions for the terms "moisture," "ash," "volatile matter" and "fixed carbon," were referred to a sub-committee of Committee E-8, under the chairmanship of H. C. Porter, which sub-committee was already giving consideration to these four terms in their relation to coke. The sub-committee has made considerable progress in revising these terms and it is expected that they can be disposed of during the coming year. The remaining two terms: namely, "proximate analysis" and "ultimate analysis," seemed to concern, at least at the present time, only the committee having prepared them. They were accordingly referred back to that committee with a discussion as to how they could be advantageously revised.

Terms Relating to Waterproofing Materials (D 147).—The three terms submitted by Committee D-8 on Waterproofing Materials are as follows:

Bituminous Grouts
Bituminous Mastics
Mastic Cake

Since these three terms obviously concern only the one committee that prepared them, they were discussed with that committee, rewordings being suggested by the Advisory Committee of Committee E-8. Committee D-8, in revising the methods containing these definitions, as outlined in the report of that committee for 1923, has rewritten the definitions in question in a manner which will probably be satisfactory to Committee E-8.

Definitions of Terms Relating to Rubber Analysis (D 15).—The four terms prepared by Committee D-11 on Rubber Products are as follows:

Organic Extract
Saponifiable Acetone Extract
Total Waxy Hydrocarbons
Unsaponifiable Resins

These terms concern only the committee that prepared the definitions and they were accordingly taken up with that committee. The suggestion of Committee E-8 that the definitions be reworded so as to make their limited applicability apparent was satisfactory to Committee D-11. The terms have been referred to letter ballot of Committee E-8 for approval, the result of the letter ballot on this recommendation being as follows: Advisory Committee, 6 affirmative, 0 negative, and 1 not voting, total 7. Standing Committees, 18 affirmative, 0 negative, and 18 not voting, total 36.

Terms Relating to Textiles (D 123).—Committee D-13 on Textile Materials, in revising the Tentative Definitions of Terms Relating to Textiles (D 123), submitted the following six additional terms:

Twill
Drills
Jeans
Alberts
Serge
Clay

These six new terms have been handled in conjunction with the terms submitted by Committee D-13 prior to 1922. As stated in connection with these terms, they have been taken up with Committee D-13, and it is expected that Committees E-8 and D-13 will be able to arrive at satisfactory definitions during the coming year.

Miscellaneous Terms.—Committee B-2 on Non-Ferrous Metals and Alloys included in its Specifications for Pig Lead (B 29), the definition of the term "virgin lead." The suggestion was made to Committee B-2 by Committee E-8 that this definition be reworded as a section on scope.

A new definition was submitted in 1922 by Committee D-2 on Petroleum Products and Lubricants, this definition being of the term "A.S.T.M. Petrolatum Melting Point" contained in the Tentative Methods D 127. In addition, two terms, "cloud point" and "pour point," appearing in the Tentative Methods D 97 and classified in 1922 as not being definitions, have been reconsidered, since the subject matter contained in these definitions reads very much like that considered to be a definition in the cases of the terms "Precipitation Number of Lubricating Oils" (D 91) and "A.S.T.M. Paraffin Wax Melting Point" (D 87). The definitions of these three terms have been taken under advisement by the Editorial Committee of the Advisory Committee.

RESUMÉ OF SUB-COMMITTEE AND OTHER ACTIVITIES

Sub-Committee on Specific Gravity.—This sub-committee, under the chairmanship of F. M. Farmer, has made a comprehensive study of the definitions for the terms "specific gravity," "relative specific gravity" and "apparent specific gravity," as given in various places in the Society's Proceedings, in many standard dictionaries, textbooks and other references. A report of the sub-committee has been presented to Committee E-8, giving the results of this study and submitting recommendations in reference to the usage of the term "density" rather than "specific gravity" and recommending definitions for the four terms "absolute specific gravity" "specific gravity," "apparent specific gravity" and "bulk specific gravity." The report is appended hereto. The Advisory Committee of Committee E-8 deemed it advisable to give considerable publicity to the report of the sub-committee, especially in view of the recommendations contained therein. The report was accordingly brought to the attention of the several standing committees of the Society, the report being transmitted with the following letter:

January 24, 1923.

TO THE CHAIRMEN AND SECRETARIES OF THE STANDING COMMITTEES

Dear Sirs:

I am sending you on behalf of the Advisory Committee of Committee E-8 on Nomenclature and Definitions a copy of the report of a Sub-Committee on Specific Gravity. On the last page of this report several recommendations appear with the suggestion by the sub-committee that Committee E-8 submit these as definite recommendations to the standing committees. Committee E-8 is not prepared to do this, however, until these recommendations have received some discussion by the standing committees concerned, especially since the first recommendation appears to be somewhat radical in that it suggests the use of the term "density" instead of the term "specific gravity." Some objection might be raised to making this change on the ground that the term "density" has in the past been treated as an exact term to be used only in abstract and mathematical discussions.

Attention is also called to the third recommendation covering the temperatures to be used in methods of determining specific gravity.

I would appreciate it if you would send me a statement on behalf of your standing committee, setting forth the views of the committee, or in case your standing committee is not interested, advise me to that effect.

Very truly yours

C. L. WARWICK,
Secretary of Committee E-8.

A considerable number of replies have already been received by Committee E-8 in reference to this report, but Committee E-8 is not yet prepared to make any definite recommendations.

Sub-Committee on Clay and Related Terms.—This sub-committee, under the chairmanship of A. S. Watts, has made considerable progress. A number of definitions have been submitted to the sub-committee for consideration and it is believed that a definite report can be presented within the coming year.

Sub-Committee on Definition of Sand and Aggregate.—Under the chairmanship of L. R. Ferguson, this sub-committee has made considerable progress toward arriving at a satisfactory definition for the term "sand." During the year the following definition prepared by the sub-committee was submitted to Committee E-8 as a whole for its consideration:

> *Sand.*—The fine granular material naturally or artificially produced by the disintegration or crushing of rock or slag.
>
> NOTE.—The size of particle and other physical characteristics should properly be taken care of in specifications and therefore no limits are mentioned in the definition.

The definition was further referred to the standing committees of the Society so that it might receive considerable publicity, since the criticisms received as a result of this publicity might prove of considerable value to Committee E-8 when the question of final approval of the definition should be considered.

Sub-Committee on Moisture and Ash (H. C. Porter, Chairman).—The scope of this sub-committee, originally appointed to consider the definitions of the terms "moisture" and "ash" as related to coke, has been enlarged so as to include the terms "volatile matter" and "free carbon." The four terms are now being considered in reference to their relation to coal as well as to coke.

Sub-Committee on Definitions of Sieve and Screen.—The organization of this sub-committee, under the chairmanship of L. R. Ferguson, has been effected, and it has already been possible to give some consideration to the terms "sieve" and "screen." The important question for this sub-committee to decide is whether any distinction should be made between a sieve and a screen, and if so, what this distinction should be, whether it is a question of the shape of aperture or whether it is a question of the type of apparatus.

Definitions of Terms Relating to Timber.—Committee D-7 on Timber, having begun a review of the definitions prepared by that committee, has enlarged the field of this review, in order to cooperate with the Central Committee on Lumber Standards, which has initiated an extended study on definitions relating to timber. As a result of this cooperative work, it is expected that Committee D-7 will report a number of revisions of the existing definitions relating to timber.

Terms Relating to Heat Treatment.—A joint committee has been organized of representatives of this Society, the Society of Automotive Engineers, and the American Society for Steel Treating to formulate definitions relating to heat treatment. The Society is represented on this joint committee by R. M. Bird, a member of Committee A-4 on Heat Treatment of Iron and Steel. The representative of the American Society for Steel Treating is J. A. Halbing. The representative of the Society of Automotive Engineers is H. P. Tiemann, a member of the Advisory Committee of Committee E-8. The work of this joint committee will thus be tied in effectively with the work which the Society is now conducting along these lines.

Terms Relating to Methods of Testing.—Committee E-1 on Methods of Testing, in connection with its work of writing methods of mechanical testing of metallic materials, found it desirable to prepare a number of definitions relating to methods of testing. Committee E-8 was consulted in an advisory capacity to assist in the preparation and review of these definitions. The definitions appear in the Report of Committee E-1 for 1923. Although not having been officially brought before Committee E-8, they have been submitted to the committee as information and will be acted upon during the coming year after their acceptance as tentative.

This report has been submitted to letter ballot of the committee with the following result: Advisory Committee, affirmative, 6; negative, 0; not voting, 1; total, 7; Standing Committees, affimative, 26; negative, 2; not voting, 8; total, 36.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

C. L. WARWICK,
Secretary.

APPENDIX

REPORT OF SUB-COMMITTEE ON SPECIFIC GRAVITY

INSTRUCTIONS

The general instructions of Committee E-8 to the sub-committee were interpreted to be as follows:

(*a*) Study the various definitions of specific gravity given by various authorities.

(*b*) Study the various definitions now given in the "Standards" and "Tentative Standards" either directly or by implication.

(*c*) Recommend definitions for specific gravity and make any other recommendations it may deem advisable.

EXISTING DEFINITIONS

The following definitions were found in such textbooks on physics and such dictionaries as were conveniently at hand. No attempt was made to make the list complete, for ample evidence was soon found to show the need of standardization of the definitions of specific gravity:

1. *"Deductive Physics" by F. J. Rogers.*—The specific gravity of a substance is the weight of a given volume of a substance as compared with the weight of an equal volume of water at 4° C.

2. *Ganot's Physics.*—If now, we take the density of distilled water at 4° C. to be unity, the relative density of any other substance is the ratio which the mass of any given volume of that substance at that temperature bears to the mass of an equal volume of water. The relative density of a substance is generally called its specific gravity.

3. *"A Textbook of Physics" by Wentworth and Toole.*—The specific gravity of a substance is the number that expresses the ratio which the weight of a given volume of the substance bears to the weight of an equal volume of a standard substance.

4. *"Physical Measurements" by Kohlrausch.*—By the density or specific gravity of a solid or liquid is meant the ratio of its mass to that of an equal volume of water at 4° C. The choice of any other temperature than 4° C. must be pronounced unscientific since the density of water at this temperature forms the basis of the metrical system.

5. *"Laboratory Manual of Physics and Applied Electricity" by E. L. Nichols.*—The specific gravity of a substance is the ratio of the weight of a given volume of the substance to the weight of an equal volume of water at its maximum density.

6. *"High School Physics" by Carhart and Chute.*—The specific gravity of a body is the ratio of the mass of any volume of it to the mass of the same volume of pure water at 4° C.

7. "*Textbook of Physics*" *by Anthony and Brackett.*—The specific gravity of a body is defined as the ratio of its weight to the weight of an equal volume of pure water at a standard temperature.

8. "*Physics Measurements*" *by Ferry.*—The specific gravity or relative density of a substance is the ratio of its density to the density of some standard substance. Water at 4° C. is arbitrarily taken as the standard substance.

9. *Century Dictionary.*—The ratio of the weight of a given bulk of any substance to that of a standard substance. The substance taken as the standard is water for solids and liquids, air or hydrogen for gases.

10. *Standard Dictionary.*—The ratio of the weight of a body to that of an equal body of some standard substance, water in the case of solids and liquids, air in the case of gases; numerically equal to density.

11. *Encyclopedia Britannica.*—The term "relative density" or "specific gravity" denotes the ratio of the mass of a certain volume of a substance to the mass of the same volume of some standard substance.

12. *Webster's New International Dictionary.*—The ratio of the weight of any volume of a substance to the weight of an equal volume of some other substance taken as the standard or unit; relative density. This standard is usually water for solids and liquids and air for gases. In the case of gases usually the weights of equal volumes at 0° and 760 mm. are compared. Solids are usually compared with water of the same temperature or with water of maximum density (at 4° C.).

The following definitions are in the existing Standards or Tentative Standards of the Society:

1. *Standard Definitions of Terms Relating to Paint Specifications (D 16).*—The ratio of the weight of a unit volume of a substance to the weight of an equal volume of water at defined temperature.

2. *Tentative Method of Test for Specific Gravity of Road Oils, etc., and also for Asphalts, etc. (D 70 - 20 T and D 71 - 20 T).*—The specific gravity of road oils, road tars, asphalt cements and soft tar pitches (or asphalts and tar pitches) shall be expressed as the ratio of the weight of a given volume of a material at 25° C. (77° F.) to that of an equal volume of water at the same temperature and shall be expressed thus:

Specific gravity 25°/25° C. (77°/77° F.).

It will be noted that no two of these definitions are exactly alike and in some cases the differences are quite important. It would seem, however, that to set up an exact definition for specific gravity by means of which *all* materials could be directly compared with each other, two conditions must be standardized: (*a*) the standard substance with which comparison is made and (*b*) the temperature at which the volume of the material is determined.

Pure water is the generally accepted material of reference for solids and liquids, while air (and sometimes hydrogen) is used for gases. We are at the present time concerned only with solids and liquids. While pure water is very generally used as the standard substance of reference, the question arises,—at what temperature shall this water be employed, 4° C., the temperature of maximum density, or some other more convenient temperature such as 20 or 25° C.? The former has a scientific basis in that a milliliter of water at that temperature weighs exactly a gram. On the other hand, all weighing methods (as distinguished from volumetric methods) involve the immersion of the material in water and obviously such measurements are more conveniently made at temperatures such as 20 and 25° C., so that if 4° C. is taken as the reference temperature of the water, a correction has to be made for the change in density. Of course in volumetric methods, the reference temperature is automatically 4° C. because the apparatus is calibrated in milliliters (usually referred to as "cc.").

REFERENCE TEMPERATURES NOW IN STANDARDS

The following tabulation shows the temperatures for the water and for the material which are now indicated in the various Standards and Tentative Standards of the Society where specific gravity is prescribed. The temperatures given are either indicated directly or by inference. For example, where a determination is made by a volumetric method, it is assumed that that is equivalent to determining the equivalent weight of water at 4° C.

Brief Title	Serial Number	Temperatures	
		Material	Water
Portland Cement	C 9	20° C.	4° C.
Refractory Materials	C 20	25° C.	25° C.
Linseed Oil	D 1	15.5 and 25° C.	15.5 and 25° C.
Linseed Oil	D 11	15.5° C.	15.5° C.
Tung Oil	D 12	15.5° C.	15.5° C.
Red Lead Analysis	D 49	?	(4° C. by Thompson method)
Pigment Analysis	D 50	?	(4° C. by Thompson method)
Lubricant Testing	D 47	15.56° C.	15.56° C.
Specific gravity Coarse Aggregates	D 30	?	?
Specific gravity Sand, etc	D 55	20° C.	4° C.
Creosote Oil Analysis	D 38	38° C.	?
Asphalt	D 40 T.	25° C.	25° C.
Coal-Tar Pitch	D 42 T.[a]	25° C.	25° C.
	[b]	60° C.	60° C.
Specific gravity Road Oils, etc	D 70 T.	25° C.	25° C.
Specific gravity Asphalts, etc	D 81 T.	25° C.	25° C.
Insulating Varnish Testing	D 115 T.	20° C.	20° C.
Turpentine	D 13 T.	15.5° C.	15.5° C.
Linseed Oil	D 77 T.	15.5° C.	15.5° C.
Linseed Oil	D 78 T.	15.5° C.	15.5° C.
Tar	D 104 T.	25° C.	25° C.
Tar	D 105 T.	25° C.	25° C.
Tar	D 108 T.	25° C.	25° C.
Tar	D 109 T	25° C.	25° C.
Tar Cement	D 106 T.	25° C.	25° C.
Tar Cement	D 107 T.	25° C.	25° C.
Tar Cement	D 110 T.	25° C.	25° C.
Tar Cement	D 111 T.	25° C.	25° C.
Coal-Tar Pitch	D 112 T.	25° C.	25° C.
Creosote Oil	D 43 T.	38° C.	?
Wires and Cables	D 27 T.	20° C.	20° C.

[a] Pitch.
[b] Distillate.

There are in many cases practical reasons for the particular temperature which has been adopted for the material but it is believed that there could be more uniformity than that shown in the above list. Also it is questionable if so many temperatures for the water are necessary, although doubtless in some cases the one adopted may be somewhat more convenient.

RECOMMENDATIONS

The sub-committee has considered several proposals including a complete series of definitions beginning with density and covering all conditions. It was concluded, however, to confine the definitions to those which would be most generally used in industrial applications.

The sub-committee is agreed on the form of a fundamental definition for specific gravity but it has not been possible to get unanimous agreement on a nomenclature. Correspondence has been had with several specially qualified men who are not on the sub-committee but there are so many fixed conceptions and so many different practices firmly established in industry and commerce that it is apparently impossible to get unanimous agreement. However, the chairman has given careful consideration to the replies to three different drafts of definitions which were sent out to the sub-committee and others for consideration and believes that the following represents the views of the greater number.

(*a*) Recommended Definitions:

Absolute Specific Gravity (of solids and liquids).—The ratio of the weight referred to vacua of a given volume of the material at a stated temperature to the weight referred to vacua of an equal volume of distilled water at a stated temperature. It shall be expressed thus:

$$\text{Absolute Specific Gravity } \frac{x^\circ \text{ C.,}}{x^\circ\text{C.}} \text{ ....,}$$

where the temperature above the line is that of the material and the temperature below the line is that of the water.

Specific Gravity (of solids and liquids).—The ratio of the weight in air of a given volume of the material at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature. It shall be expressed thus:

$$\text{Specific Gravity } \frac{x^\circ \text{ C.,}}{x^\circ \text{ C.}} \text{ ....,}$$

where the temperature above the line is that of the material and the temperature below the line is that of water.

Apparent Specific Gravity (of solids).—The ratio of the weight in air of a given volume of the impermeable portion of a permeable material (that is solid matter plus sealed pores or voids) at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature. It shall be expressed thus:

$$\text{Apparent Specific Gravity } \frac{x^\circ\ \text{C.}}{x^\circ\ \text{C.}} \ \ldots\ldots\ldots\ldots,$$

where the temperature above the line is that of the material and the temperature below the line is that of water.

Bulk Specific Gravity (of solids).—The ratio of the weight in air of a given volume of a permeable material (including both permeable and impermeable matter) at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature. It shall be expressed thus:

$$\text{Bulk Specific Gravity } \frac{x^\circ\ \text{C.},}{x^\circ\ \text{C.}} \ \ldots\ldots\ldots\ldots,$$

where the temperature above the line is that of the material and the temperature below the line is that of water.

(*b*) It is suggested that Committee E-8 make the following recommendations to the Standing Committees:

1. That since density is a basic fundamental quantity, which is easier and more definitely defined, and therefore less confusing, it be used instead of specific gravity, *where it is feasible to do so.*
2. That, if and when it is feasible to do so, existing definitions for specific gravity, whether stated directly or by inference by means of a prescribed method of determining it, be revised where necessary to conform to those given above.
3. That where there is no particular reason for adopting other values, the standard reference temperature for the material be 25° C. and for the water, 4° C.

Respectfully submitted on behalf of the sub-committee,

F. M. FARMER,
Chairman.

A.S.T.M.
TENTATIVE STANDARDS
SUBMITTED OR REVISED

AT THE

1923 ANNUAL MEETING

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards its adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee whose name and address appear in the footnote to the title of each Tentative Standard.

TENTATIVE SPECIFICATIONS
FOR
BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE.[1]

Serial Designation: A 70 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1916; REVISED, 1917, 1918, 1921, 1923.

Material Covered.

1. These specifications cover two classes of steel for boilers for stationary service, namely: flange and firebox.

I. MANUFACTURE.

Process.

2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The steel shall conform to the following requirements as to chemical composition:

		FLANGE.	FIREBOX	
Carbon	For plates ¾ in. or under in thickness	.....	not over 0.25	per cent
	For plates over ¾ in. in thickness	.....	" " 0.30	"
Manganese	For plates ¾ in. or under in thickness	0.30–0.60	0.30–0.50	"
	For plates over ¾ in. in thickness	0.30–0.60	0.30–0.60	"
Phosphorus	Acid	not over 0.05	not over 0.04	"
	Basic	" " 0.04	" " 0.035	"
Sulfur		" " 0.05	" " 0.04	"

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

6. (*a*) The material shall conform to the following requirements as to tensile properties:

	FLANGE AND FIREBOX.
Tensile strength, lb. per sq. in.	55 000 – 65 000
Yield point, min., " "	0.5 tens. str.
Elongation in 8 in., min., per cent	$\frac{1\ 550\ 000}{\text{Tens. str.}}$

(*b*) Should the above rule for minimum allowable elongation give a value of less than 25 per cent for firebox steel, the minimum allowable elongation shall be 25 per cent, subject to the modifications of Section 7.

(*c*) The yield point shall be determined by the drop of the beam of the testing-machine.

Modifications in Elongation.

7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentage of elongation specified in Section 6 (*a*) of 0.125 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*b*) For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

Bend Tests.

8. The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Homogeneity Tests.

9. For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:

The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $\frac{1}{16}$ in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite

ERRATA

Section 6 (*a*).—Change the requirements for tensile properties given in Section 6 (*a*) to read as follows:

	FLANGE	FIREBOX
Tensile strength, lb. per sq. in.	55 000 – 65 000	55 000 – 65 000
Yield point, min., lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 8 in., min. per cent (See Section 7)	$\frac{1\ 500\ 000}{\text{Tens. str.}}$	$\frac{1\ 550\ 000}{\text{Tens. str.}}$

side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about $\frac{1}{4}$ in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

Test Specimens.

10. (*a*) Tension test specimens shall be taken longitudinally from the bottom of the finished rolled material, and bend test specimens shall be taken transversely from the middle of the top of the finished rolled material. The longitudinal test specimen shall be taken in the direction of the longitudinal axis of the ingot, and the transverse test specimen at right angles to that axis.

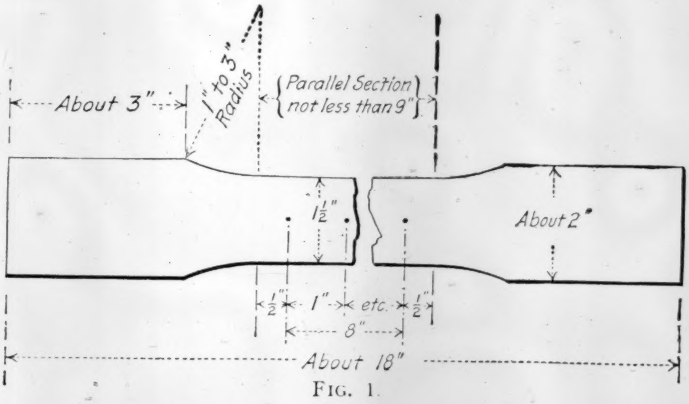

FIG. 1.

(*b*) Tension and bend test specimens shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

Number of Tests.

11. (*a*) One tension and one bend test shall be made from each plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS

Permissible Variations. 12. The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[1] in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

V. FINISH.

Finish. 13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108in., excl.	108 to 120in., excl.	120 to 132in., excl.	132 in. or over.	
Under 1/8	9	10	12	14	..	..	..	..	..	Under 1/8
1/8 to 3/16 excl.	8	9	10	12	..	..	..	..	..	1/8 to 3/16 excl.
3/16 " 1/4 "	7	8	9	10	12	..	..	..	..	3/16 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

VI. MARKING.

Marking. 14. (*a*) The name or brand of the manufacturer, the manufacturer's test identification number, class and lowest tensile strength specified shall be legibly stamped on each finished plate in two places not less than 12 in. from the edges and on each butt strap near the center line not less than 12 in. from each end. The manufacturer's test identification number shall be legibly stamped on each test specimen.

(*b*) When specified on the order, plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When more than one plate is sheared from a single slab or ingot, each shall be match-marked so that they may all be identified with the test specimens representing them.

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[1] The term "lot" applied to Table I means all of the plates of each group width and group thickness.

(*c*) Each match mark shall consist of two over-lapping circles each not less than 1 $\frac{1}{2}$ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

VII. INSPECTION AND REJECTION.

Inspection. 15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5, shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing 17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
STEEL PLATES OF STRUCTURAL QUALITY FOR FORGE WELDING.[1]

Serial Designation: A 78 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1919; REVISED, 1920, 1921, 1923.

Material Covered. 1. These specifications cover steel plates of structural quality suitable for forge welding without the addition of fluxes.

I. MANUFACTURE.

Process. 2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. (*a*) The steel shall conform to the following requirements as to chemical composition:

		GRADE A.	GRADE B.
Carbon	for plates $\frac{3}{4}$ in. or under in thickness	not over 0.15 per cent	not over 0.20 per cent
	for plates over $\frac{3}{4}$ in. in thickness	" 0.17 "	" 0.22 "
Manganese		0.35 to 0.60 "	0.35 to 0.60 "
Phosphorus		not over 0.06 "	not over 0.06 "
Sulfur		" 0.05 "	" 0.05 "

(*b*) The composition of the steel should preferably be free from silicon, nickel or chromium. Where these elements are present the maximum quantity of any one shall not exceed 0.05 per cent.

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

Check Analyses.

5. An analysis may be made by the purchaser from a broken tension test specimen representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	GRADE A.	GRADE B.
Tensile strength, lb. per sq. in.	45,000	50,000
Yield point, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
but in no case less than	24,000	27,000
Elongation in 8 in., per cent	28	25

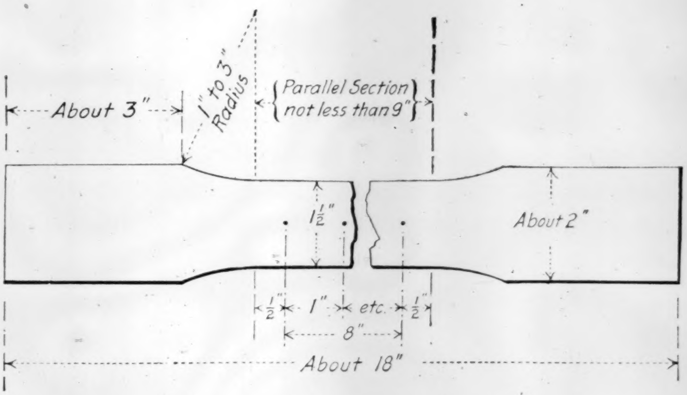

FIG. 1.

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation.

7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentages of elongation specified in Section 6 (*a*) of 0.25 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*b*) For material under $\frac{5}{16}$ in. in thickness a deduction from the percentages of elongation specified in Section 6 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness below $\frac{5}{16}$ in.

Bend Tests.

8. The test specimen shall withstand being bent cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens.

9. (*a*) Test specimens shall be prepared for testing from the material in its rolled condition.

(*b*) Test specimens shall be taken longitudinally and, except as specified in Paragraph (*c*), shall be of the full thickness of material as rolled. They may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*c*) Test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in.

(*d*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests.

10. (*a*) One tension and one bend test shall be made from each melt; except that if material from one melt differs $\frac{3}{8}$ in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variation.

11. The cross-section or weight of plates shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(*a*) *When Ordered to Weight per Square Foot:* The weight of each lot[1] in each shipment shall not vary from the weight ordered more than the amount given in Table I.

(*b*) *When Ordered to Thickness:* The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[2] in each shipment shall not exceed the amount given in Table II.

V. FINISH.

Finish.

12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking.

13. The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

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[1] The term "lot" applied to Table I means all of the plates of each group width and group weight.

[2] The term "lot" applied to Table II means all of the plates of each group width and group thickness.

VII. INSPECTION AND REJECTION.

Inspection. 14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these

TABLE I.—PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT.

Ordered Weight, lb. per sq. ft.	Permissible Variations in Average Weights per Square Foot of Plates for Widths Given. Expressed in Percentages of Ordered Weights.																		Ordered Weight, lb. per sq. ft.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over.		
	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	
Under 5........	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl..	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 " .	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 " .	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 " .	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 " .	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 " .	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 " .	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 " .	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 " .	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over......	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than $1\frac{1}{3}$ times the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given. Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over.	
Under $\frac{1}{8}$............	9	10	12	14	..	..	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl........	8	9	10	12	..	..	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over............	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 15. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
STEEL PLATES OF FLANGE QUALITY FOR FORGE WELDING.[1]

Serial Designation: A 89 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923.

Material Covered.

1. These specifications cover steel plates of flange quality suitable for forge welding without the addition of fluxes.

I. MANUFACTURE.

Process.

2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. (*a*) The steel shall conform to the following requirements as to chemical composition:

		GRADE A.	GRADE B.
Carbon	for plates ¾ in. or under in thickness	not over 0.15 per cent	not over 0.20 per cent
	for plates over ¾ in. in thickness	" " 0.17 "	" " 0.22 "
Manganese		0.35 to 0.60 "	0.35 to 0.60 "
Phosphorus	Acid	not over 0.06 "	not over 0.06 "
	Basic	" " 0.04 "	" " 0.04 "
Sulfur		" " 0.05 "	" " 0.05 "

(*b*) The composition of the steel should preferably be free from silicon, nickel or chromium. Where these elements are present the maximum quantity of any one shall not exceed 0.05 per cent.

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. An analysis may be made by the purchaser from a broken tension test specimen representng each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 6. (*a*) The material shall conform to the following minimum requirements as to tensile properties.

	GRADE A.	GRADH B.
Tensile strength, lb. per sq. in......	45,000	50,000
Yield point, lb. per sq. in..........	0.5 tens. str.	0.5 tens. str.
but in no case less than.......	24,000	27,000
Elongation in 8 in., per cent.......	30	27

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation. 7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction from the percentages of elongation specified in Section 6 (*a*) of 0.125 per cent shall be made for each increase of $\frac{1}{32}$ in. of the specified thickness above $\frac{3}{4}$ in.

(*b*) For material under $\frac{5}{16}$ in. in thickness, a deduction from the percentage of elongation in 8 in. specified in Section 6 (*a*) of 1.25 per cent shall be made for each decrease of $\frac{1}{32}$ in. of the specified thickness below $\frac{5}{16}$ in.

Bend Tests. 8. The test specimen shall withstand being bent cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Test Specimens. 9. (*a*) Tension test specimens shall be taken longitudinally from the bottom of the finished rolled material, and bend test specimens shall be taken transversely from the middle of the top of the finished rolled material. The longitudinal test specimens shall be taken in the direction of the longitudinal axis of the ingot, and the transverse test specimens at right angles to that axis.

(*b*) Tension and bond test specimens shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

(*c*) Test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness or diameter of at least $\frac{3}{4}$ in. for a length of at least 9 in.

(*d*) The machined sides of rectangular bend test specimens may have the corners rounded to a radius not over $\frac{1}{16}$ in.

Number of Tests. 10. (*a*) One tension and one bend test shall be made from each plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variations.

11. The thickness of each plate shall not vary more than 0.01 in. under that ordered.

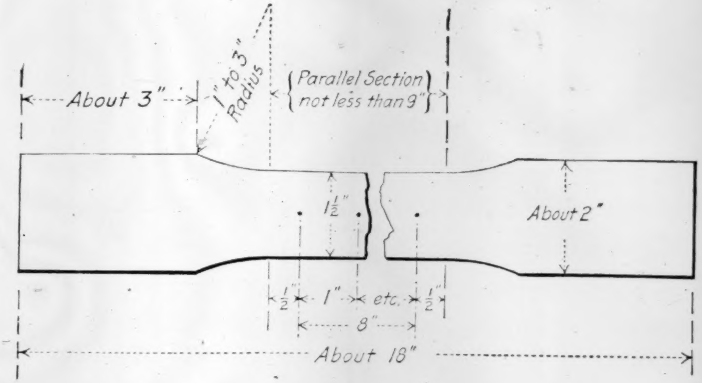

FIG. 1.

The overweight of each lot[1] in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

V. FINISH.

Finish.

12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking.

13. (*a*) The name or brand of the manufacturer, melt or slab number, class, and lowest tensile strength for its class specified in Section 6 (*a*) shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen.

(*b*) When specified on the order, plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When more than one plate is sheared from a single slab or ingot, each shall be match-marked so that they may all be identified with the test specimen representing them.

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[1] The term "lot" applied to Table I means all of the plates of each group width and group thickness.

(*c*) Each match mark shall consist of two over-lapping circles each not less than $1\frac{1}{2}$ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

VII. INSPECTION AND REJECTION.

Inspection. 14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in. excl.	84 to 96 in., excl.	96 to 108 in. excl.	108 to 120 in., excl.	120 to 132 in. excl.	132 in. or over	
Under $\frac{1}{8}$	9	10	12	14	..	..	..	..	..	Under $\frac{1}{8}$
$\frac{1}{8}$ to $\frac{3}{16}$ excl	8	9	10	12	..	..	..	..	..	$\frac{1}{8}$ to $\frac{3}{16}$ excl.
$\frac{3}{16}$ " $\frac{1}{4}$ "	7	8	9	10	12	..	..	..	..	$\frac{3}{16}$ " $\frac{1}{4}$ "
$\frac{1}{4}$ " $\frac{5}{16}$ "	6	7	8	9	10	12	14	16	19	$\frac{1}{4}$ " $\frac{5}{16}$ "
$\frac{5}{16}$ " $\frac{3}{8}$ "	5	6	7	8	9	10	12	14	17	$\frac{5}{16}$ " $\frac{3}{8}$ "
$\frac{3}{8}$ " $\frac{7}{16}$ "	4.5	5	6	7	8	9	10	12	15	$\frac{3}{8}$ " $\frac{7}{16}$ "
$\frac{7}{16}$ " $\frac{1}{2}$ "	4	4.5	5	6	7	8	9	10	13	$\frac{7}{16}$ " $\frac{1}{2}$ "
$\frac{1}{2}$ " $\frac{5}{8}$ "	3.5	4	4.5	5	6	7	8	9	11	$\frac{1}{2}$ " $\frac{5}{8}$ "
$\frac{5}{8}$ " $\frac{3}{4}$ "	3	3.5	4	4.5	5	6	7	8	9	$\frac{5}{8}$ " $\frac{3}{4}$ "
$\frac{3}{4}$ " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	$\frac{3}{4}$ " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

Rejection. 15. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
STEEL CASTINGS.[1]

Serial Designation: A 27 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923.

Material Covered.

1. These specifications cover steel castings for general service and for ships. Two classes of castings are covered: namely,

Class A, castings for which no physical requirements are specified.

Class B, castings for which physical requirements are specified. These are of three grades: hard, medium, and soft.

I. MANUFACTURE.

Process.

2. The steel shall be made by one or more of the following processes: open-hearth, electric furnace, converter, or crucible.

Heat Treatment.

3. (*a*) Class A castings need not receive any heat treatment unless so specified, or unless the carbon content exceeds 0.30 per cent.

(*b*) Class B castings shall receive a proper heat treatment, the treatment depending upon the design and chemical composition of the castings.

(*c*) Heat treatment shall be in accordance with the Tentative Recommended Practice for Heat Treatment of Carbon-Steel Castings (Serial Designation: A 36 – 22 T), of the American Society for Testing Materials,[2] unless otherwise specified by the purchaser.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. The castings shall conform to the following requirements as to chemical composition:

		CLASS A.	CLASS B.
Carbon		not over 0.45 per cent	....
Phosphorus	Acid	" " 0.07 "	not over 0.06 per cent
	Basic	" " 0.06 "	" " 0.05 "
Sulfur		....	" " 0.06 "

Ladle Analyses.

5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Steel Castings (Serial Designation: A 27 – 21), 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 643 (1922).

Section 4. This analysis shall be made from drillings taken at least ¼ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 4.

Check Analyses.

6. (*a*) Analyses of Class A castings may be made by the purchaser. The phosphorus content thus determined shall not exceed that specified in Section 4 by more than 20 per cent. Samples for analysis shall be taken not less than ¼ in. beneath the surface, and in such a way as not to destroy the castings.

(*b*) Analyses of Class B castings may be made by the purchaser from a broken tension test specimen. The phosphorus and sulfur content thus determined shall not exceed that specified in Section 4 by more than 20 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

(FOR CLASS B CASTINGS ONLY.)

Tension Tests.

7. (*a*) The castings shall conform to the following minimum requirements as to tensile properties:

	HARD.	MEDIUM.	SOFT.
Tensile strength, lb. per sq. in..	80 000	70 000	60 000
Yield point, lb. per sq. in......	0.45 tens. str.	0.45 tens. str.	0.45 tens. str.
Elongation in 2 in., per cent...	17	20	24
Reduction of area, " ...	25	30	35

(*b*) No maximum limit shall be placed on the tensile strength in any of the grades.

(*c*) The yield point shall be determined by the drop of the beam of the testing machine.

Bend Tests.

8. (*a*) Bend tests shall not be required for castings of the hard grade, and shall be required for castings of the medium and soft grades only when so specified in the order.

(*b*) When a bend test is specified, the test specimen shall withstand being bent cold without cracking on the outside of the bent portion, around a pin 1 in. in diameter to the following angles:

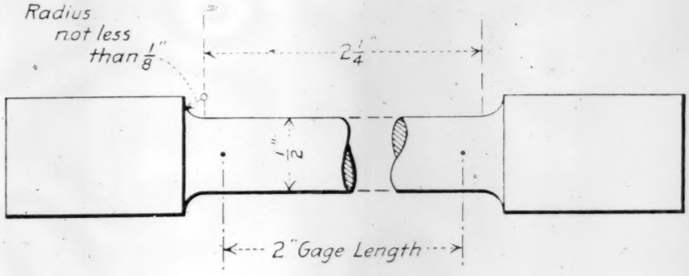
	HARD.	MEDIUM.	SOFT.
Angle of bend..........	No Bend Test	90 deg.	120 deg.

Alternative Tests to Destruction.

9. The tensile properties of the castings shall be determined from test bars unless in the case of castings weighing not over 150 lb. the manufacturer desires to offer, as an alternative, tests to destruction. Upon agreement with the inspector, the castings shall be grouped in lots, each lot containing castings from the same melt and from the same heat-treatment charge, and the inspector shall select

from each lot one casting to represent the lot. The representative casting shall be tested to destruction as a substitute for the tension test. This test shall show the material to be ductile and free from injurious defects.

Test Specimens. 10. (*a*) Tension and bend test specimens shall be taken from test bars cast attached to the castings where practicable. If the design of the castings is such that test bars should not be attached to the castings, the test bars shall be cast attached to special blocks, of which a sufficient number shall be provided for each lot of castings. Tets bars from which tension and bend test specimens are to be taken shall remain attached to the castings or blocks they represent through heat treatment and until presented for inspection. Test bars shall be provided in sufficient numbers to furnish the tests required in Section 11.



Note:—The Gage Length, Parallel Portions and Fillets shall be as Shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.

FIG. 1.

(*b*) If satisfactory to the manufacturer and inspector, tension test specimens may be cut from heat-treated castings instead of from test bars.

Tension Specimens. (*c*) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Bend Specimens. (*d*) Bend test specimens shall be machined to 1 by $\frac{1}{2}$ in. in section with the corners rounded to a radius of not over $\frac{1}{16}$ in.

Number of Tests. 11. (*a*) One tension test and, when specified, one bend test shall be made from each melt in each heat-treatment charge and, when specified, from each casting weighing 500 lb. or over.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case another specimen from the same lot shall be substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests. 12. If the results of the physical test for any lot do not conform to the requirements specified, such lot may be retreated, but not more than twice. Retests shall be made as specified in Sections 7 and 8.

IV. WORKMANSHIP AND FINISH.

Workmanship. 13. The castings shall conform substantially to the shapes and sizes indicated by the patterns and drawings submitted by the purchaser.

Finish. 14. (*a*) The castings shall be free from injurious defects.

Welding. (*b*) Defects which do not impair the strength of the castings may be welded by an approved process. The defects shall be cleaned out to solid metal, before welding, and when so required by the inspector, shall be submitted to him in this condition for his approval. When required by the inspector, important castings shall be heat-treated after welding.

V. INSPECTION AND REJECTION.

Inspection. 15. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications.

(*b*) If, in the case of important castings for special purposes, surface inspection in the green state is required, this shall be so specified in the order.

(*c*) All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(*b*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected and the manufacturer shall be notified.

Rehearing. 17. Samples tested in accordance with Section 6, which represent rejected castings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

VI. SPECIAL REQUIREMENTS FOR CASTINGS FOR SHIPS.

Castings for Ships. 18. In addition to the preceding requirements, castings for ships, when so specified, shall conform to the following requirements:

Heat Treatment. 19. All castings shall be of Class B, medium or soft grade, and shall receive a proper heat treatment.

Number of Tests. 20. (*a*) One tension and one bend test shall be made from each of the following castings: stern frames, stern posts, twin screw spectacle frames, propeller shaft brackets, rudders, steering quadrants, tillers, stems, anchors, and other castings when specified.

(*b*) When a casting is made from more than one melt, four tension and four bend tests shall be made from each casting.

Percussion Tests. 21. (*a*) A percussion test shall be made on each of the following castings: stern frames, stern posts, twin screw spectacle frames, propeller shaft brackets, rudders, steering quadrants, tillers, stems, anchors, and other castings when specified.

(*b*) For this test, the casting shall be suspended by chains and hammered all over with a hammer of a weight approved by the purchaser or his representative. If cracks, flaws, defects, or weakness appear after such test, the casting may be rejected.

TENTATIVE METHODS OF TEST
FOR
MAGNETIC PROPERTIES OF IRON AND STEEL[1]

Serial Designation: A 34 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923.

A. Normal Induction and Hysteresis.

I. DEFINITIONS.

Definitions. 1. (*a*) *Normal Induction.*—The induction produced under a given magnetizing force in a substance which has been previously demagnetized and then subjected to a sufficient number of reversals of the given magnetizing force to bring it to a cyclic condition.

Both the induction and magnetizing force shall be expressed in terms of the c.g.s. electromagnetic units (gauss and gilbert per centimeter, respectively).

(*b*) *Magnetic Permeability.*—The ratio of the normal induction to the magnetizing force which produces it. Thus:

$$\text{Permeability} = \frac{\text{Gausses}}{\text{Gilberts per centimeter}}$$

(*c*) *Residual Induction.*—The magnetic induction which exists in a substance after the magnetizing force has been reduced to zero.

NOTE.—If the induction has been reduced from a point on the normal induction curve it is called the normal residual induction.

(*d*) *Coercive Force.*—The negative value of magnetizing force required to reduce the induction in a substance to zero.

NOTE.—If the induction has been reduced to zero from a point on the normal induction curve the coercive force is called the normal coercive force.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

These methods, when adopted as standard, will supersede the present Standard Methods of Test for Magnetic Properties of Iron and Steel (Serial Designation: A 34 - 18), 1921 Book of A.S.T.M. Standards.

II. METHODS OF TEST.

2. The tests shall be made either by the ring method or by means of any permeameter having the required accuracy as specified below.

Specimens.

3. Ring specimens shall not be welded but shall be cut in a solid piece, and shall have a radial width of 3 cm. ($1\frac{3}{16}$ in.). The mean diameter shall not be less than 30 cm. ($11\frac{13}{16}$ in.).

In the preparation of samples of sheet steel, the dies or shears used shall be sharp.

Standard Densities.

4. (*a*) The cross-section of sheet steel samples shall be calculated from assumed or measured values of length, mass, and density.

(*b*) For silicon and aluminum steels, a density of 7.7 shall be assumed where the silicon and aluminum content is 2 per cent or less[1] and a density of 7.5 shall be assumed where the silicon and aluminum content is over 2 per cent. For nickel steel a density of 7.7 shall be assumed. For other alloys a density corresponding to the actual measured or calculated value shall be used.

III. ACCURACY.

Accuracy.

5. (*a*) Values of magnetizing force obtainable with ring specimens under the conditions specified above shall be considered to be correct within 1 per cent.

(*b*) Permeameters shall be considered satisfactory if they yield, either directly or with the aid of suitable corrections, values having the following accuracy: For normal induction, the values of magnetizing force corresponding to inductions up to 14,000 gausses shall be correct within 5 per cent; values of induction greater than 14,000 shall be correct within 2 per cent. For residual induction, values shall be correct within 2 per cent, and for coercive force, values shall be correct within 5 per cent.

IV. REFERENCE METHODS.

6. In order to determine the accuracy of permeameters they shall be checked by means of samples which have been standardized as follows:

(*a*) For use with material having a maximum permeability not exceeding 10,000 the standard samples may be calibrated by the Burrows compensated double-yoke method having magnetizing coils not less than 20.3 cm. (8 in.) in length. The ratio of the area of the test coil to that of the specimen shall be such that the air correction factor shall be not greater than 3. This air correction may be applied by calculation or eliminated by means of an adjustable mutual inductance having its primary connected in series with the main permeameter magnetizing winding and its secondary in series with the main test coil. This mutual inductance shall be set to such a value that the flux in the space between the sample and the test coil shall be automatically compensated for.

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[1] For silicon steel having a 2-per-cent silicon content the electrical resistance is 2.6 ohms per meter gram.

(*b*) For material having a maximum permeability exceeding 10,000 an elongated ring or link-shaped sample having parallel sides of substantially equal cross-sections shall be used. These shall be calibrated by winding with uniformly distributed primary and secondary windings and testing ballistically like a ring sample. This type of sample may also be used for checking permeameters for use with the lower permeability material instead of the method described in Paragraph (*a*).

(*c*) For material to be tested at magnetizing forces exceeding 200 gilberts per cm. the modified isthmus method described in the U. S. Bureau of Standards *Scientific Papers Nos. 361* and *383* shall be used.

7. Care must be exercised in all cases that the standardized samples are magnetically homogeneous and clamped so as to be free from mechanical strain.

V. STANDARD DATA.

8. (*a*) The standard normal induction data for all magnetic materials shall consist of the values of magnetizing force corresponding to inductions of 2000, 4000, 6000, 8000, 10,000, 12,000, 14,000, 16,000, 18,000, and 20,000 gausses.

(*b*) Residual induction and coercive force values for sheet steel and materials of the type used for electromagnet cores shall be determined from a normal induction of 10,000 gausses.

(*c*) For permanent magnet steel, the normal induction, residual induction and coercive force shall be determined from a maximum magnetizing force of 200 gilberts per cm. unless the maximum permeability is less than 100, in which case the maximum magnetizing force shall be not less than 2½ times the value of magnetizing force at which this maximum occurs and shall be some multiple of 200. Samples of magnet steel shall be hardened previous to testing in accordance with best metallurgical practice for the steel in question.

B. Core Loss.

VI. DEFINITIONS

Definitions

9. (*a*) *Core Loss.*—The power consumption in electrical sheet steel when subjected to an alternating magnetization.

(*b*) *Standard Core Loss.*—The total power in watts consumed in each kilogram of material at a temperature of 25° C. when subjected to a harmonically varying induction having a maximum of 10,000 gausses and a frequency of 60 cycles per second, when measured as specified below. It is represented by the symbol $W_{10/60}$.

(*c*) *Aging Coefficient.*—The percentage change in the standard core loss after continued heating at 100° C. for 600 hours.

VII. PROCEDURE.

Conditions of Testing.

10. The standard core loss shall be measured under the following conditions:

(*a*) The magnetic circuit shall consist of 10 kg. (22 lb.) of the test material, cut with a sharp shear into strips 50 cm. ($19\frac{11}{16}$ in.) in length and 3 cm. ($1\frac{3}{16}$ in.) in width, one-half parallel and one-half at right angles to the direction of rolling, made up into four equal bundles, two containing material parallel and two containing material at right angles to the direction of rolling, and finally built into the four sides of a square with butt joints and opposite sides consisting of material cut in the same manner. No insulation other than the natural scale of the material (except in the case of scale-free material) shall be used between laminations, but the corner joints may be separated by tough paper 0.1 mm. (0.004 in.) in thickness.

(*b*) The magnetizing winding shall consist of four solenoids surrounding the four sides of the magnetic circuit and joined in series. A secondary coil shall be used for energizing the voltmeter and the potential coil of the wattmeter.

These solenoids shall be wound on a form of any non-magnetic non-conducting material of the following dimensions:

Inside cross-section	4 by 4 cm.
Thickness of wall	not over 0.3 cm.
Winding length	42 cm.

The primary winding on each solenoid shall consist of 150 turns of copper wire uniformly wound over the 42-cm. length. The total resistance of the magnetizing winding shall be between 0.3 and 0.5 ohm. The secondary winding of 150 turns of copper wire on each solenoid shall be similarly wound beneath the primary winding. Its resistance shall not exceed 1 ohm.

(*c*) A voltmeter and the voltage coil of a wattmeter shall be connected in parallel to the terminals of the secondary winding of the apparatus. The current coil of the wattmeter shall be connected in series with the primary winding.

(*d*) An electromotive force having a wave form approximating a sine curve shall be applied to the primary winding and adjusted until the voltage of the secondary circuit is given by the equation:

$$E = \frac{4 f N n B M}{4 l D 10^8}\cdot$$

in which

f = form factor of primary E.M.F. . . . = 1.11 for sine wave
N = number of secondary turns. . . . . . $\doteq$ 600
n = number of cycles per second. . . . . = 60
B = maximum induction. . . . . = 10,000
M = total mass in grams. . . . . = 10,000
l = length of strips in centimeters . . . = 50

$$D = \text{density} \ldots\ldots\ldots\ldots = \begin{cases} 7.5 \text{ for high-resistance steel} \\ 7.7 \text{ for low-resistance steel} \end{cases}$$

$$E = \begin{cases} 106.6 \text{ volts for high-resistance steel for sine voltage} \\ 103.8 \text{ volts for low-resistance steel for sine voltage} \end{cases}$$

The form factor of the applied electromotive force shall not depart more than 1 per cent from the value of 1.11. As an alternative to the use of a sine wave, the correct value of the voltage may be determined by applying it to an Epstein apparatus containing a sample which has been standardized by means of a sine wave electromotive force. The wattmeter is brought to the correct reading for the standard sample. The corresponding voltage is the correct one to use.

Standard Densities.

11. For silicon and aluminum steels a density of 7.7 shall be assumed where the silicon and aluminum content is 2 per cent or less[1] and a density of 7.5 shall be assumed where the silicon and aluminum content is over 2 per cent. For other alloys a density corresponding to the actual measured or calculated value shall be used.

12. The wattmeter gives the power consumed in the iron and the secondary circuit. The loss in the secondary circuit is given in terms of the total resistance and voltage. Subtracting this correction term from the total power gives the net power consumed in the steel as hysteresis and eddy-current loss. Dividing this value by ten gives the core loss in watts per kilogram.

Sampling.

13. The core-loss material shall be cut from two or more sheets taken at random from the shipment. The strips should be distributed symmetrically over the sheet, as nearly as may be practicable. (See Figs. 1 and 2.)

It is recommended that a test sample shall represent not more than 5000 kg. (11,000 lb.).

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[1] For silicon steel having a 2-per-cent silicon content the electrical resistance is 2.6 ohms per meter gram.

Procedure.

14. (*a*) Cut the test material into strips 3 by 50 cm. as indicated in Section 13.

(*b*) Place on the balance a pile of strips weighing 2.5 kg. Add a second pile of the same kind, bringing the weight up to 5 kg. In each case the weight is taken to the nearest strip. Add in succession two piles of 2.5 kg. each, of the other kind of strips, bringing the weight up to 7.5 kg. and 10 kg., respectively.

(*c*) Secure each bundle by string or tape (not wire) and insert in the apparatus as indicated.

(*d*) Apply the alternating voltage to the primary coil and tap the joints together until the current has a minimum value, as shown by an ammeter in series. Then clamp the corners firmly by some suitable device.

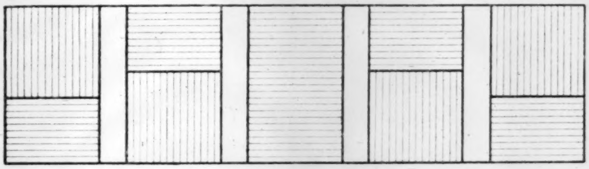

FIG. 1.

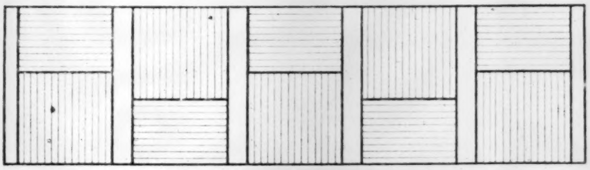

FIG. 2.

(*e*) Shunt the ammeter and adjust the primary current until the voltmeter indicates the proper value. This adjustment may be made by an auto-transformer, by varying the field of the alternator, or by both, but not by the insertion of resistance or inductance in the primary circuit. Simultaneously the frequency must be adjusted to 60 cycles.

(*f*) Read the wattmeter.

(*g*) *Calculations.*—Subtract from the wattmeter reading the instrument losses, which will be constant for any set of instruments and voltage, and divide by 10. The result is the standard core loss.

NOTE.—If desired a 5-kg. sample may be used for routine acceptance tests, provided it is cut from at least two sheets, except in case of a dispute between the manufacturer and purchaser when the 10-kg. sample shall be used.

TENTATIVE METHODS OF DETERMINING WEIGHT OF COATING ON ZINC-COATED ARTICLES[1]

Serial Designation: A 90 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

SHOP WEIGHING TESTS

Select a pickled and washed sheet. Stand the sheet on edge and allow to drain for 2 minutes. The water remaining on the sheet will then amount to approximately 0.01 lb. per sq. ft.

Weigh this sheet with an accuracy of 0.05 lb., and subtract the weight of the water to obtain the real weight of the uncoated sheet. After galvanizing, reweigh the sheet. The increase in weight represents the coating.

Where greater accuracy is desired, wash, dry and weigh ten sheets; then coat and reweigh.

To determine the weight of coating in ounces per square foot, divide the weight of coating in ounces by the area in square feet in the sheet or sheets.

SAMPLING

(*a*) *Sheets.*

The laboratory samples for determining the average weight of coating upon a galvanized sheet shall be taken as follows:

A $2\frac{1}{2}$-in. strip shall be cut transversely or diagonally across the middle of the sheet with its ends approximately 1 in. from each edge. Three samples, $2\frac{1}{4}$ by $2\frac{1}{4}$ in., shall be accurately cut from the middle and the two ends of this strip. These samples shall be cleaned with gasoline or benzol, then with alcohol and dried thoroughly before proceeding with the test.

The weight of coating in grams on a $2\frac{1}{4}$ by $2\frac{1}{4}$-in. piece (5.08 sq. in.) is numerically equal to the coating in ounces per square foot.

(*b*) *Wire.*

Select either exactly 1 ft. of wire, or a definite length of wire as given in Table I, depending upon the diameter of the wire after stripping. Clean the wire with gasoline or benzol, then with alcohol, and dry thoroughly.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. D. M. Buck, Secretary of Committee A-5 on Corrosion of Iron and Steel, Frick Building, Pittsburgh, Pa.

When using exactly 12-in. of wire for the test and obtaining the loss of weight (weight of coating) in grams, the formula is as follows:

$$\frac{\text{Loss of Weight in grams}}{7.422\times\text{diameter in inches of stripped wire}}=\text{Ounces per square foot of actual surface}$$

It is sometimes more convenient to use a length of wire, as given in Table I, such that the loss in weight (weight of coating) in grams will numerically equal the ounces per square foot of actual surface.

TABLE I.—LENGTHS OF WIRE TO GIVE GRAMS OF COATING WHICH ARE NUMERICALLY EQUAL TO OUNCES PER SQUARE FOOT OF ACTUAL SURFACE

SIZE OF WIRE, B. W. G.	DIAMETER, IN.	LENGTH FOR TEST IN.	CM.
0	0.340	$4\frac{3}{4}$	12.1
1	0.300	$5\frac{3}{8}$	13.7
2	0.284	$5\frac{11}{16}$	14.5
3	0.259	$6\frac{1}{4}$	15.9
4	0.238	$6\frac{13}{16}$	17.3
5	0.220	$7\frac{3}{8}$	18.7
6	0.203	$7\frac{15}{16}$	20.2
7	0.180	9	22.8
8	0.165	$9\frac{13}{16}$	24.9
9	0.148	$10\frac{15}{16}$	27.7
10	0.134	$12\frac{1}{16}$	30.6
11	0.120	$13\frac{1}{2}$	34.2
12	0.109	$14\frac{13}{16}$	37.7
13	0.095	17	43.2
14	0.083	$19\frac{1}{2}$	49.5
15	0.072	$22\frac{7}{16}$	57.0
16	0.065	$24\frac{7}{8}$	63.2
17	0.058	$27\frac{7}{8}$	70.8
18	0.049	33	83.8

By multiplying by two, the figures for coating in ounces per square foot of actual surface may be compared with the figures for coating in ounces per square foot on zinc-coated sheets.

HYDROCHLORIC ACID - ANTIMONY CHLORIDE METHOD

(STANDARD METHOD)

SOLUTIONS REQUIRED

Antimony Chloride Solution.—Dissolve 20 g. of antimony trioxide or 32 g. of $SbCl_3$ in 1000 cc. of HCl (sp. gr. 1.19).

Hydrochloric Acid.—Concentrated HCl (sp. gr. 1.19).

METHOD

(*a*) *Sheets.*

Cut three $2\frac{1}{4}$ by $2\frac{1}{4}$-in. laboratory samples, as described under Sampling and weigh together[1] after cleaning and drying. They should be immersed singly in 100 cc. of hydrochloric acid (sp. gr. 1.19) to which has been added 5 cc. of antimony chloride solution, and allowed to remain therein until the evolution of hydrogen has ceased or until only a few bubbles are being evolved. This requires only about 15 to 30 seconds, except in the case of sherardized coatings which require a somewhat longer time. The same 100 cc. of hydrochloric acid can be used for at least 5 samples, but 5 cc. of the antimony chloride solution should be added before the immersion of each sample. After stripping, the samples should be washed and scrubbed under running water, dried with a towel and laid in a warm place for a short time. The samples should again be weighed together[1] and the number of grams lost divided by the number of samples taken. Each gram then corresponds numerically to one ounce of coating per square foot.

(*b*) *Wire.*

A small section of the zinc-coated wire should be stripped in hydrochloric acid containing antimony chloride, and the diameter of the stripped wire determined.

To determine the weight of coating, the sample is carefully weighed to 0.01 g. The wire is then placed in a tall cylinder containing hydrochloric acid (sp. gr. 1.19) to which has been added 2 to 3 cc. of antimony chloride solution of the same strength as is used in the testing of sheets. After stripping, the wire is washed under running water, dried, and laid in a warm place for a short time. The loss in weight represents the zinc coating, and if the length of wire designated in Table I is used, the coating in grams will be numerically equal to the coating in ounces per square foot of actual surface. In order to compare this figure with that given for sheets, it must be multiplied by two.

BASIC LEAD ACETATE METHOD

(ALTERNATE METHOD)

SOLUTIONS REQUIRED

Lead Acetate Solution.—Dissolve 400 g. of crystallized lead acetate in 1 liter of water. When dissolved, add 4 g. of finely powdered litharge and after thorough agitation, allow the solution to settle and decant the clear portion for use.

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[1] If it is of interest to know the individual weight of coating on each piece, each must be analyzed individually instead of collectively as described.

METHOD

Cut three $2\frac{1}{4}$ by $2\frac{1}{4}$-in. laboratory samples, clean and weigh as described in the Hydrochloric Acid - Antimony Chloride Method.[1] The samples should then be submerged separately in a tumbler containing sufficient lead acetate solution to cover the samples. The samples should be maintained in an upright position in order to enable the lead acetate to attack all portions.

After being immersed about three minutes, the sample should be taken out and the adherent lead carefully removed under running water in order that no burnishing action will cause the lead to plate onto the sample. Four immersions of three minutes each are usually sufficient to remove all zinc from the sample, when the bright surface of the iron will be exposed. The test pieces should then be washed in water, dried carefully and weighed. The loss in grams divided by the number of samples represents the weight of coating in grams, which is numerically equal to the weight of coating in ounces per square foot.

SULFURIC ACID PERMANGANATE METHOD

(ALTERNATE METHOD)

SOLUTIONS REQUIRED

Distilled water should be used in all cases where water is mentioned as a reagent.

Standard Potassium Permanganate, 0.1 N.—Dissolve pure, crystallized potassium permanganate in water in the proportion of 3.2 g. per liter. Allow to stand at least two weeks and filter through asbestos. Standardize the solution in the following manner:

Weigh accurately 0.45 to 0.5 g. of U. S. Bureau of Standards' sodium oxalate. Place in a 400-cc. beaker and dissolve in 250 cc. of water at 80 to 90° C. Add 10 cc. of sulfuric acid composed of 5 cc. of water and 5 cc. of c.p. H_2SO_4 (sp. gr. 1.84) and titrate the solution at once with the potassium permanganate solution, stirring the liquid vigorously and continuously. The permanganate must not be added more rapidly than 10 to 15 cc. per minute and the last 0.5 to 1 cc. must be added dropwise with particular care to allow each drop to be completely decolorized before the next is introduced. The solution should not be below 60° C. by the time the end point is reached. More rapid cooling may be prevented by allowing the beaker to stand on a small asbestos-covered electric hot plate during the titration. The use of a small thermometer as a stirring rod is most convenient. Calculate the iron equivalent of the permanganate solution using the iron value furnished by the Bureau of Standards for the sodium oxalate used.

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[1] If it is of interest to know the individual weight of coating on each piece, each must be analyzed individually instead of collectively as described.

Sulfuric Acid.—Mix 100 cc. c.p. H_2SO_4 (sp. gr. 1.84), with 900 cc. of water.

METHOD

Carefully weigh the $2\frac{1}{4}$ by $2\frac{1}{4}$-in. piece, containing exactly 5.08 sq. in.

After determining the weight of the plate, place the piece in a 250-cc. beaker (Griffin form). Allow the piece to rest on or come in contact with a small piece of platinum foil. Add 125 cc. or a sufficient amount of the sulfuric acid solution to cover the inclined piece. Cover the beaker with a watch glass and allow the zinc coating to dissolve. In from ten to twenty minutes the zinc will be dissolved, as will be indicated by the cessation of the rapid evolution of gas, disregarding the small amount of gas coming mainly from the edges of the plate, due to the action of the acid on the base plate. Wash the plate with a jet of water from a wash bottle, allowing the washings to run into the beaker. Wipe the plate dry, and immediately titrate the solution in the beaker with the standard potassium permanganate solution and calculate the weight of iron dissolved with the zinc coating. Weigh the plate, and subtract this weight from the weight of the plate before removal of the coating. From the difference deduct the weight of iron found to have been dissolved with the coating, which will give the weight in grams of zinc coating on 5.08 sq. in. of the sample. The weight of the zinc coating in grams on the $2\frac{1}{4}$ by $2\frac{1}{4}$-in. piece will be numerically equal to the weight of zinc coating in ounces per square foot.

APPENDIX

FIELD TESTS FOR DETERMINATION OF ZINC-COATED ARTICLES

PREECE OR COPPER SULFATE DIP TEST

The samples for the Preece test may be of any size, but should be free from as much cut surface as possible, and should be carefully cleaned before starting the test. The samples are then dipped into not less than 100 cc. of copper sulfate solution maintained at a temperature of 18° C. The samples are allowed to remain exactly one minute in the solution. They are then washed in running water, and the copper deposit lightly rubbed off. Successive immersions of one minute each are continued, with the washing and cleaning of the sample between each one, until the appearance of bright adherent copper indicates that the iron beneath the coating has been exposed. Should a small amount of copper be coated adherently to the zinc coating, it must not be mistaken for the end point in which the copper plates out onto the iron. The appearance of copper within one inch of a cut surface is likewise not considered to be the end point of the test.

The copper sulfate solution is prepared by dissolving 36 parts of commercial copper sulfate crystals in 100 parts of water, then adding enough cupric oxide to neutralize any free acid. The solution is filtered or allowed to settle and decanted, then diluted with water until its specific gravity is 1.186 at 18° C. It should always be used at this temperature.

When material is tested by the Preece or copper sulfate method, the number of one-minute immersions which the sample shall withstand is specified.

The amount of coating removed by a one-minute immersion in the copper sulfate solution is roughly between 0.20 and 0.25 oz. per sq. ft. of actual surface, or double this per square foot of sheets.

This test is not as accurate in determining the average weight of coating upon a sample as is the hydrochloric acid - antimony chloride method, but is useful, however, in determining which are the thinnest portions of the coating.

THERMAL METHOD[1]

This method makes possible the determination of the zinc coating on iron and steel sheets and other articles without necessitating the use of an analytical balance. An accurately measured galvanized sample is immersed in a measured amount of acid, the maximum temperature rise being recorded. Each 0.1° rise in temperature is equivalent to a definite weight of zinc.

The apparatus necessary for conducting this test is as follows:

1. Testing jar, about $2\frac{1}{2}$ in. in inside diameter, with a capacity of about 400 cc., flaring at the top if possible.
2. Thermometer, graduated in 0.1° C., with a range of about 50° C.
3. 300-cc. graduated cylinder.
4. Glass-stoppered bottle containing concentrated hydrochloric acid (sp. gr. 1.19).
5. Rule for measuring.

The sample is cleaned with gasoline, dried and accurately measured. For testing zinc-coated sheet, the usual $2\frac{1}{4}$ by $2\frac{1}{4}$-in. specimen may be used, and for wire, suitable lengths may be used as given in the table under Sampling of Wire.

A measured amount of hydrochloric acid (usually 200 cc.) is poured into the testing jar. The temperature of the acid is recorded after stirring, and the sample is immersed in the acid, care being taken that the acid does not overflow the jar. During this time, and until the coating has been stripped from the piece, the temperature is watched until the highest point is reached and the temperature starts to decline. The rise in temperature is then recorded, and from a table of factors prepared for various quantities of acid, the amount of zinc may be calculated. From the number of grams of zinc and the area of the piece in square inches, the weight of coating may be calculated as follows:

$$\text{Coating, ounces per square foot, actual surface} = \text{Weight of zinc in grams} \times \frac{5.08 \text{ sq. in.}}{\text{Area, sq. in.}}$$

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[1] Described in paper by D. M. Strickland, "A Method for Determining the Spelter Coating on Iron and Steel Sheets by Measuring the Rise in Temperature of the Acid Employed," *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part II, p. 227 (1922).

In this formula, the total area, that is, both sides of the sheet, is measured. To place this on the ordinary sheet basis, as expressed on zinc-coated sheet, the above figure should be doubled. For very light coatings (about 1 oz. per sq. ft.) 100 cc. of acid are sufficient. With coatings of 2½ oz. per sq. ft. or heavier, 300 cc. of acid should be used. To standardize the equipment, 5 or 6 zinc-coated specimens of any convenient gage or size are weighed, the rise in temperature determined for the apparatus, thermometer and volume of acid. The samples are washed, dried and reweighed, and the difference in weight noted. The weight loss in grams is divided by the corresponding rise in temperature in degrees. When carefully determined, the average of the above 5 or 6 determinations will give a conversion factor which is reliable for the equipment used and for the volume of acid employed. Factors may be determined for any volume of acid in like manner.

EVOLUTION OF HYDROGEN METHOD

This method consists in measuring the hydrogen evolved from the action of hydrochloric acid containing antimony chloride upon a definite area of galvanized surface. By this method, it is not required to cut any portion of the article to be tested, as with the Cushman coating tester, a 2½-in. ring is sealed to a portion of the surface. Acid is then added which attacks the coating within the area of the ring, and the evolved hydrogen is measured by a suitable gas burette. After removal of the spent acid, the stripped spot is washed, dried and may either be painted or coated with a suitable metallic coating. The article is, therefore, not mutilated. A full description of the test is found in the 1920 Proceedings of the American Society for Testing Materials.[1]

The results obtained by this method check very closely with those obtained by the regular hydrochloric acid - antimony chloride method. The main objection to this method is the fact that the coating upon only one side of a sheet is obtained, and as the coating upon galvanized sheets is not always exactly the same on each side; doubling the figures obtained on one side of the sheet will not always give the real amount of coating on both sides of the sheet.

This tester finds use, however, when it is necessary to test sheets or culverts already installed, and where it is desired that the articles shall not be mutilated as would be necessary in taking a regular sample.

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[1] Allerton S. Cushman, "A New Method of Testing Galvanized Coatings," *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part II, p. 411 (1920).

TENTATIVE METHODS OF DETERMINING WEIGHT OF COATING ON TIN, TERNE, AND LEAD-COATED SHEETS[1]

Serial Designation: A 91 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

SAMPLING

From each grade or shipment take one sheet for analysis. Cut four 2 by 2 in. pieces; one from each of the four sides of the sheet, parallel with and about $\frac{1}{2}$ in. from the sides, and near the middle of each side,—or cut similar samples from corner, middle, and opposite corner of the sheet, keeping in at least one inch from the edge in each case.

NOTE.—For more accurate work, nine samples are cut, three from across the top, three across the middle, and three across the bottom of each sheet.

DETERMINATION OF WEIGHT OF COATING

METHOD

Clean the laboratory samples with chloroform, carbon tetrachloride, benzol or gasoline and finally with alcohol, and dry thoroughly; then weigh accurately the four pieces together.

Wrap a stiff platinum or nickel wire about the 2 by 2 in. piece in such a manner that it may be held in the acid in a horizontal position. Using a 400-cc. beaker, heat from 60 to 150 cc. of sulfuric acid (sp. gr. 1.84) to 250° C. Immerse the sample for about one minute in the hot acid, then remove and momentarily immerse in 50 cc. of distilled water contained in a 600-cc. beaker. Rub the surface with a "policeman," while washing with about 50 cc. of distilled water from a wash bottle. If the coating has not been completely removed, again immerse in the acid and repeat the procedure. Treat all four samples in the same manner, using the same acid. Thoroughly dry and reweigh the samples. If desired, the samples may be retained for the analysis of the base metal.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. D. M. Buck, Secretary of Committee A-5 on Corrosion of Iron and Steel, Frick Building, Pittsburgh, Pa.

The loss in weight represents the coating together with some iron.

Cool the sulfuric acid in which the samples were stripped and combine with the washings in a 600-cc. beaker. Pour the solution into a 1000-cc. volumetric flask, and rinse the beaker with hydrochloric acid (sp. gr. 1.12). Add rinsings to the flask and fill to the mark with hydrochloric acid of the same strength, again adjusting to the mark if necessary after cooling.

If it is desired to make a direct determination of the lead, the lead chloride should all be in solution. For heavy lead-coated sheets it may, therefore, be necessary to dilute the solution to 2000 cc. with hydrochloric acid (sp. gr. 1.12), in order to have all the lead chloride in solution.

The solution may now be analyzed for iron, tin, lead or any other elements.

DETERMINATION OF IRON

METHOD

Remove an aliquot portion of 200 cc. from the 1000-cc. volumetric flask to a 600-cc. beaker. Add 1 or 2 cc. of a saturated solution of potassium permanganate to oxidize the iron and tin, and heat the solution to boiling. Cool and add a slight excess of ammonia. Filter the solution and wash the precipitate with hot water. Dissolve the precipitate in the original beaker with hydrochloric acid (sp. gr. 1.12), and hot water. Evaporate the hydrochloric acid solution to a volume of about 10 cc. and reduce with stannous chloride.

To the cooled solution add a mixture of 25 cc. of a saturated mercuric chloride solution, 10 cc. of phosphoric acid manganese sulfate solution and 400 cc. of boiled distilled water. Titrate immediately with 0.1 *N* potassium permanganate solution. Calculate the amount of iron stripped from the four pieces, from the number of cubic centimeters of permanganate used.

CALCULATION OF THE WEIGHT OF COATING

From the loss in weight of the four 2 by 2-in. pieces, subtract the amount of iron found by the above test. This figure represents the weight of coating in grams on the four pieces.

CALCULATION FACTORS

The weight of coating in grams on the four 2 by 2-in. pieces
multiplied by 4.3210 = weight of coating in pounds per box of 112
sheets, 14 by 20 in.

multiplied by 8.6421 = weight of coating in pounds per case of 112 sheets, 20 by 28 in.

multiplied by 0.3175 = weight of coating in ounces per square foot.

Pounds of coating per case of 112 sheets, 20 by 28 in., multiplied by 0.03673 = ounces per square foot.

Ounces per square foot multiplied by 27.22 = pounds per case of 112 sheets, 20 by 28 in.

DETERMINATION OF TIN ON TERNE PLATE

METHOD

Remove an aliquot portion of 200 cc. from the volumetric flask. Place in a 300-cc. Erlenmeyer flask, and add 1 g. of powdered antimony. Fit the flask with a one-hole rubber stopper containing a glass tube bent twice at right angles, with the end of the short bend projecting through the stopper, the other end being long enough to reach almost to the bottom of a beaker placed on a level with the flask. This beaker contains about 300 cc. of dilute sodium bicarbonate solution made up with boiled distilled water.

Place the flask on the hot plate, with the glass tube extending into the beaker of sodium bicarbonate solution. After boiling for about five minutes, substitute the beaker of dilute sodium bicarbonate solution with another containing about 50 cc. of a saturated solution of sodium bicarbonate dissolved in boiled distilled water, and remove both the beaker and flask to a cool place. This will cause a small amount of sodium bicarbonate to enter the flask and exclude the air. Finally bring the solution to a low temperature. Add several cubic centimeters of starch solution and titrate with 0.05 *N* iodine solution. It is desirable to run a duplicate analysis for tin adding the iodine quickly to a point slightly less than the end point found in the previous determination, then finishing the titration.

From these determinations, calculate the percentage of tin in the coating. In the case of tin plate, the amount of tin can be calculated to pounds per box or pounds per case by factors given under Calculation of Weight of Coating.

DETERMINATION OF LEAD ON TERNE PLATE

METHOD

After ascertaining that all the lead chloride is in solution, remove an aliquot portion of 100 cc. from the volumetric flask and place in a

400-cc. beaker. Add 10 cc. of sulfuric acid (sp. gr. 1.84), cover, and evaporate to fumes of sulfuric anhydride. Cool and dilute to 300 cc. with water. Allow to settle and then filter on a weighed Gooch crucible, washing with 5-per-cent sulfuric acid solution. Dry and ignite at a dull red heat. Cool and reweigh. The gain in weight multiplied by 0.6831 equals the weight of lead, from which calculate the percentage of lead in the sample.

DETERMINATION OF TIN ON TIN-COATED SHEETS

METHOD

Bend or cut up each sample and place each in a separate Erlenmeyer flask and cover with about 40 cc. of strong hydrochloric acid. Connect each flask through a rubber stopper with a source of pure oxygen-free carbon dioxide. Dissolve on a hot plate with carbon dioxide passing through to exclude air. Cool the flask in running water and titrate immediately with standard iodine solution, using starch indicator. The iodine solution is made up so that 1 cc. is equivalent to 0.005786 g. of tin, and is standardized against pure tin. The number of cubic centimeters of iodine used divided by ten reads directly in pounds of tin per base box of plate.

NOTE.—A base box contains 112 sheets, 14 by 20 in., and weighs 100 lb.

When it is desired to analyze only a small number of samples, satisfactory results may be obtained by adding to the flask, with the sample, a small pinch of pure powdered antimony. Cover with a watch glass and dissolve at boiling temperature. As soon as solution is complete, insert a rubber stopper with glass tube extending just through the stopper, and bent twice at right angles, the long end extending approximately level with the bottom of the flask. Insert the long end of the tube into a dilute solution of sodium bicarbonate. Place the flask in cold running water, and as the flask cools, the bicarbonate solution is sucked into the flask, the carbon dioxide set free driving out the air. As soon as cool, titrate as above.

TENTATIVE SPECIFICATIONS
FOR
ROUND AND GROOVED HARD-DRAWN COPPER TROLLEY WIRE[1]

Serial Designation: B 47 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923.

I. MANUFACTURE

Scope.

1. These specifications cover round and grooved trolley wire.

Material.

2. The material used shall be electrolytic or low-resistance lake copper conforming in quality and purity to the requirements of either the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5) or of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4) of the American Society for Testing Materials.[2]

II. PHYSICAL PROPERTIES AND TESTS

(*A*) *Round Wire.*—

Tensile Strength and Elongation.

3. (*a*) The wire shall be so drawn that its tensile strength and elongation shall not be less than the values given in Table I.

The elongation shall be determined as the permanent increase in length due to the breaking of the wire in tension measured between bench marks placed upon the wire originally 10 in. apart. The fracture shall be between the bench marks and not closer than 1 in. to either bench mark.

(*b*) Tests upon a section of wire containing a braze shall show at least 95 per cent of the tensile strength of the unbrazed wire.

Elongation tests shall not be made on test sections including brazes.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] 1921 Book of A.S.T.M. Standards.

Resistivity. 4. Electric resistivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.). The wire shall not exceed in resistivity 900.77 lb. per mile-ohm.

(B) Grooved Wire.—

Physical Properties and Tests. 5. (*a*) The physical tests shall be made in the same manner as those upon the round wire. The tensile strength of grooved wire shall be at least 95 per cent of that required for round wire of the same cross-sectional area; the elongation shall be the same as that required for round wire of the same cross-sectional area. The twist test shall be omitted.

TABLE I.—VALUES FOR TENSILE STRENGTH AND ELONGATION

Diameter, in.	Area, circular mils	Tensile Strength, lb. per sq. in.	Elongation in 10 in., per cent
0.548	300 000	47 000	4.50
0.460	211 600	49 000	3.75
0.410	168 100	51 000	3.25
0.365	133 225	52 800	2.80
0.325	105 625	54 500	2.40

(*b*) Tests upon a section of wire containing a braze shall show at least 95 per cent of the tensile strength of the unbrazed wire.

Elongation tests shall not be made on test sections including brazes.

Resistivity. 6. The requirements for resistivity shall be the same as those for round wire of the same cross-sectional area.

III. DIMENSIONS AND PERMISSIBLE VARIATIONS

Specific Gravity. 7. For the purpose of calculating weights, cross-sections, etc., the specific gravity of the copper shall be taken as 8.89 at 20° C. (68° F.).

(A) Round Wire.—

Dimensions and Permissible Variations. 8. (*a*) The size shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals, *i. e.*, in mils.

(*b*) Wire is expected to be accurate in diameter. Variations of 1 per cent over or under the nominal diameter shall be permitted.

(B) Grooved Wire.—

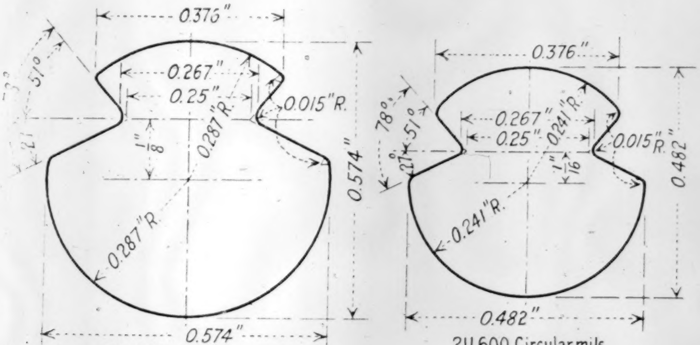
Sections.

9. Standard sections of grooved trolley wire shall be those known as the "American Standard Grooved Trolley Wire Sections" (the Standard Design of the American Electric Railway Engineering Association), shown in Fig. 1.

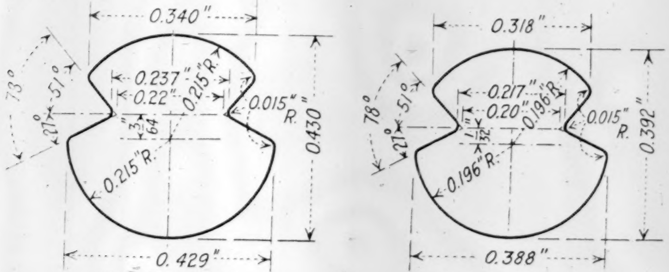
Dimensions and Permissible Variations.

10. (*a*) Size shall be expressed as the area of cross-section in circular mils, the standard sizes being as follows:

300 000 circular mils weighing 4,795 lb. per mile
211 600 " " " 3,382 " " "
168 100 " " " 2,687 " " "
133 200 " " " 2,129 " " "


0.376"
0.267"
0.25"
0.287"R.
0.015"R.
1/8"
0.574"
0.287"R.
73°
51°
27°
0.574"
0.376"
0.267"
0.25"
0.241"R.
0.015"R.
1/16"
0.482"
0.241"R.
78°
51°
27°
0.482"

300 000 Circular mils. 211 600 Circular mils.


0.340"
0.237"
0.22"
0.215"R.
0.015"R.
3/64"
0.430"
0.215"R.
73°
51°
27°
0.429"
0.318"
0.217"
0.20"
0.196"R.
0.015"R.
1/32"
0.392"
0.196"R.
78°
51°
27°
0.388"

168 100 Circular mils. 133 200 Circular mils.

FIG. 1.

(*b*) Grooved trolley wire may vary 4 per cent over and under in weight per unit length from the standard as determined from the nominal cross-section.

IV. FINISH

Finish.

11. (*a*) The wire shall be of uniform size, shape, and quality throughout, and shall be free from all scale, flaws, splits and scratches not consistent with the best commercial practice.

(*b*) Necessary brazes in trolley wire shall be made in accordance with the best commercial practice.

V. PACKING

Packing and Shipping.

12. All wire shall be shipped on substantial reels, suitable for the weight of the wire handled, and shall be well protected from injury. The length or weight of wire to be wound upon reels shall be agreed upon in placing individual orders.

VI. INSPECTION AND REJECTION

Inspection.

13. (*a*) All tests governing the acceptance or rejection of the wire, unless otherwise specified, shall be made at the place of manufacture with apparatus furnished by the manufacturer and in the presence of the purchaser, or his representative, who shall be furnished a copy of the tests. Every facility shall be given the purchaser, or his representative, to satisfy him as to the reliability of the results before the wire is delivered. If the purchaser waives inspection, and if he so elects at that time, he shall be furnished with a certified copy of tests made by the producer.

(*b*) For the purpose of determining and developing defects which may be prejudicial to the life of trolley wire, owing to its peculiar service, as compared to that of copper wire for other purposes, the wire shall be subjected to the following twisting test. Three twist tests shall be made upon samples 10 in. in length between the holders of the machine. The twisting machine shall be so constructed that there is a linear motion of the tail stock with respect to the head. The twist shall be applied not faster than 10 turns per minute. All three samples shall be twisted to destruction and shall not reveal under test any seams, pits, slivers, or surface imperfections not consistent with the best commercial practice. At the time of fracture the wire shall be twisting with reasonable uniformity. Wire shall not be considered satisfactory which does not withstand at least nine turns before breaking.

Rejection.

14. Any reel of wire which fails to meet the requirements hereinbefore specified may be rejected. Failure of 30 per cent of the number of reels ready for inspection at one time may be deemed sufficient cause for the rejection of the whole lot.

TENTATIVE SPECIFICATIONS
FOR
SOFT RECTANGULAR COPPER WIRE[1]

Serial Designation: B 48 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923.

I. MANUFACTURE

Scope. 1. These specifications cover soft or annealed rectangular copper wire with rounded corners.

Material. 2. The copper shall conform in quality and purity to the requirements of either the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 4) or of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials.[2]

II. PHYSICAL PROPERTIES AND TESTS

Physical Tests. 3. The wire shall conform to the following requirements as to tensile properties:

THICKNESS, IN.	MAXIMUM TENSILE STRENGTH, LB. PER SQ. IN.	MINIMUM ELONGATION IN 10 IN., PER CENT
0.003 to 0.010	......	14
0.011 to 0.020	40 000	20
0.021 to 0.050	38 500	25
0.051 to 0.289	37 000	30
0.290 to 0.500	36 000	33

The elongation shall be measured between bench marks placed upon the wire originally 10 in. apart and the fracture shall be between the bench marks and not closer than 1 in. to either bench mark. If upon testing a sample from any coil or reel, the results do not conform to the specified requirements two additional samples shall be tested and the average of the three tests shall determine acceptance or rejection of the coil or reel.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] 1921 Book of A.S.T.M. Standards.

Electric Resistivity.

4. Electric resistivity (Note 1) shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.) and shall not exceed 891.58 lb. per mile-ohm.

III. DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions and Permissible Variations.

5. (*a*) The permissible variation in thickness, above or below the specified thickness, for different widths shall not exceed the limits given in the following table (Note 2):

Specified Thickness, in.	Permissible Variations		
	½ in. or Less in Width	Over ½ in. to 1 in. in Width	Over 1 In. in Width
0.050 or less	0.001 in.	0.001 in.	0.0015 in.
0.051 to 0.100	0.001 in.	0.001 in.	0.002 in.
0.101 to 0.200	1 per cent	1 per cent	0.0025 in.
0.201 to 0.300	1 per cent	1 per cent	0.003 in.
0.301 to 0.500	0.003 in.	1 per cent	1 per cent
0.501 or over	....	1 per cent	1 per cent

(*b*) A variation of ±0.003 in. will be permitted in the width of wire 0.300 in. or less in width; wire 0.301 to 1.50 in. in width may vary ±1 per cent; wire greater than 1.50 in. in width shall not vary more than ±0.016 in. from the specified width.

(*c*) Dimensions shall be expressed in decimals of an inch.

(*d*) Rectangular wire shall have edges with corners rounded to a radius as given in the following table:

Thickness, in.	Width, 0 to 0.438 in.	Width, 0.439 to 0.625 in.	Width, 0.626 in. or Over
0.050 or less	Half Round	Half Round	Half Round
0.051 to 0.105	0.025	Half Round	Half Round
0.106 to 0.125	0.031	Half Round	Half Round
0.126 to 0.165	0.031	0.047	0.063
0.166 to 0.225	0.047	0.047	0.063
0.226 to 0.438	0.063	0.063	0.094
0.439 to 0.688	.....	0.094	0.125
0.689 and above	.....	.....	0.188

Each coil shall be gaged at three places, one near each end and one approximately at the middle. From reels, approximately 12 ft. shall be reeled off; the wire shall be gaged in six places between the second and twelfth foot from the end. A coil or reel may be rejected if the average of the measurements obtained is not within the limits specified in Paragraphs (*a*) or (*b*).

IV. FINISH

Finish.

6. (*a*) The wire shall be free from all imperfections not consistent with the best commercial practice.

(*b*) Necessary brazes shall be made in accordance with the best commercial practice.

(*c*) The copper shall be thoroughly annealed after the last drawing or rolling.

V. PACKING

Packages. 7. (*a*) Rectangular wire shall be shipped in coils or on reels as agreed upon by the purchaser and the manufacturer (Note 3).

(*b*) The wire shall be packed so as to be properly protected against injury during shipment.

(*c*) Unless otherwise agreed upon, the wire shall be shipped in continuous lengths as follows:

THICKNESS, IN.	WIDTH, IN.	MINIMUM WEIGHT PER LENGTH, LB.
Less than 0.025	0.500 or less	5
Less than 0.010	Over 0.500	5
0.010 to 0.019, inclusive	Over 0.500	10
0.025 to 0.034, “	0.500 or less	15
0.020 to 0.094, “	Over 0.500 to 0.750	25
0.020 to 0.094, “	Over 0.750 to 1.00	35
0.020 to 0.094, “	Over 1.00	50
0.035 to 0.094, “	0.500 or less	20
0.095 to 0.300, “	0.500 or less	40
0.301 to 0.500, “	0.500 or less	100
Over 0.094	Over 0.500	100

Specific Gravity. 8. For the purpose of calculating weights, cross-sections, etc., the specific gravity of the copper shall be taken as 8.89 at 20° C. (68° F.) (Note 4).

VI. INSPECTION

Inspection. 9. Test and inspection shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to the requirements of these specifications.

EXPLANATORY NOTES

Soft or annealed copper wire is wire which has been drawn and rolled by customary operations and annealed, and finished by cleaning when necessary to remove scale or oxide. The wire is so soft and ductile that it is easily marred and even stretched by careless handling, hence the necessity for confining specifications and inspection to wire in packages as it leaves the manufacturer, and before being put through processes incident to its use by the purchaser.

NOTE 1.—During the year 1913 the following resistivity was agreed upon internationally as standard for annealed copper:

0.15328 ohm per meter-gram at 20° C.

This resistivity is known as the International Annealed Copper Standard[1] and is equivalent to:

875.20 ohms per mile-pound at 20° C.
0.017241 ohm per meter-millimeter squared at 20° C.
1.7241 microhms per centimeter cubed at 20° C.
0.67879 microhms per inch cubed at 20° C.
10.371 ohms per mil-foot at 20° C.

For reducing the resistance of annealed copper from one temperature to another the following temperature coefficients should be used:

At 0° C., 0.00427; at 15° C., 0.00401; at 20° C., 0.00393; at 25° C., 0.00385.

In case it is desired to express the resistivity of copper in terms of conductivity, the International Annealed Copper Standard at 20° C. should be taken as 100-per-cent conductivity, and in reporting conductivity values this standard should be mentioned. It has been deemed preferable to express the requirements in standard specifications in the terms of quantities directly measurable, rather than by reference to some quantity whose standard value is the subject of agreement only. The use of the arbitrary term "conductivity" has no more warrant than the employment of arbitrary gage numbers. Therefore, in these specifications the requirements are stated as the maximum rejection limits to the resistivity.

For the convenience of those who are accustomed to express resistivity in any one of the several more or less common units, the following table of equivalents has been prepared, giving the resistivity of copper at 20° C.

887.05 lb. per mile-ohm is equal to:
  0.15535 ohms per meter-gram,
  1.7475 microhms per centimeter-cube,
  0.68799 microhms per inch-cube,
  10.512 ohms per mil-foot.
891.58 lb. per mile-ohm is equal to:
  0.15614 ohms per meter-gram,
  1.7564 microhms per centimeter-cube,
  0.69150 microhms per inch-cube,
  10.565 ohms per mil-foot.

NOTE 2.—The use of arbitrary gage numbers to express dimensions cannot be too strongly condemned. There are many such gages in existence, and confusion is to be expected unless the particular gage to be used is specified. Many of the gages have their dimensions stated in absurd figures, such as 0.090742 in., when it is not practical to measure dimensions in the fourth decimal place by workshop tools. Definite dimensions in measurable units are evidently preferable.

NOTE 3.—Attention is called to the necessity for the purchaser and manufacturer agreeing on the package weights which will be standard under any individual contract.

NOTE 4.—The specific gravity of copper was formerly standardized in A.S.T.M. specifications at 8.90. The value has been changed to 8.89, since that is the value adopted as standard by the American Institute of Electrical Engineers and the International Electro-Technical Commission.

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[1] See U. S. Bureau of Standards *Circular No. 31* for further details.

TENTATIVE SPECIFICATIONS

FOR

HOT-ROLLED COPPER RODS FOR WIRE DRAWING[1]

Serial Designation: B 49 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

I. MANUFACTURE

Scope. 1. These specifications cover black hot-rolled copper rods for wire-drawing purposes.

Material. 2. The copper shall conform in quality and purity to the requirements of either the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 4) or of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials.[2]

3. (*a*) The rod shall be hot rolled from standard wire bars.

(*b*) The rods shall be furnished in one continuous length without joints.

II. PHYSICAL PROPERTIES AND TESTS

Physical Tests. 4. (*a*) The rods shall conform to the following requirements as to tensile properties:

The elongation in 10 in. shall not be less than 25 per cent. The elongation shall be measured between bench marks placed upon the wire originally 10 in. apart and the fracture shall be between the bench marks and not closer than 1 in. to either bench mark. If upon testing a sample from any coil or reel the results do not conform to the specified requirements, two additional samples shall be tested and the average of the three tests shall determine acceptance or rejection of the coil or reel.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] 1921 Book of A.S.T.M. Standards.

(*b*) Two tests shall be made from each carload of 50,000 lb. or less.

Electric Resistivity.

5. Electric resistivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.) and shall not exceed 891.58 lb. per mile-ohm.

III. DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions and Permissible Variations.

6. (*a*) The size shall be expressed as the diameter of the rod in decimal fractions of an inch.

(*b*) The rods shall be hot rolled to nominal size within the following permissible variations:

DIAMETER, IN.	PERMISSIBLE VARIATIONS, IN.	DIAMETER, IN.	PERMISSIBLE VARIATIONS, IN.
0.250	+0.020	0.875	±0.020
0.3125	±0.010	1.00	±0.020
0.375	±0.010	1.125	±0.020
0.500	±0.015	1.250	±0.020
0.625	±0.015	1.375	±0.030
0.750	±0.015		

Sizes between those listed shall take the variation for the next larger size in the table.

Specific Gravity.

7. For the purpose of calculating weights, cross-sections, etc., the specific gravity of the copper shall be taken as 8.89 at 20° C (68° F.).

IV. FINISH

Finish.

8. The rod shall be free from all imperfections not consistent with the best commercial practice.

V. PACKING

Packages.

9. Unless otherwise agreed upon, the rods shall be shipped in coils approximately 24 in. in inside diameter and each coil shall be bound tightly together with copper wire at two points approximately opposite to each other.

VI. INSPECTION

Inspection.

10. The tests and inspection shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to assure him that the material conforms to all the requirements of the specifications.

TENTATIVE SPECIFICATIONS

FOR

SEAMLESS ADMIRALTY CONDENSER TUBES AND FERRULE STOCK[1]

Serial Designation: B 44 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1922; REVISED, 1923

Material Covered.

1. These specifications cover seamless tubes and ferrule stock made from Admiralty alloy for condenser use.

I. MANUFACTURE

Process.

2. The tubes shall be cold drawn to size from an alloy made from lake or electrolytic copper, conforming to the requirements of either the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4) or the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials,[2] and zinc of Grade No. 1 of the Standard Specifications for Spelter (Serial Designation: B 6) of the American Society for Testing Materials,[2] and Straits tin or its equivalent. Scrap shall not be used except such as may result from the manufacture of articles of the same composition.

Annealing.

3. (*a*) Condenser tubes shall be annealed sufficiently to enable the tubes to pass the physical and metallographic tests herein specified.

(*b*) Tubes for ferrule stock shall be sufficiently annealed to prevent cracking, but they need not be held within the close limits specified for condenser tubes.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

4. The material shall conform to the following requirements as to chemical composition (Note 1):

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

Copper	not less than 70.00 per cent
Tin	0.90 to 1.20 "
Lead	not over 0.075 "
Iron	not over 0.06 "
Zinc	remainder

Sampling. 5. The sample for chemical analysis shall consist of drillings, millings, or clippings taken from at least three separate tubes from each lot of 600 tubes or less, equal quantities being taken from each tube and thoroughly mixed. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for the seller, one for the purchaser, and one for an umpire, if necessary.

III. PHYSICAL PROPERTIES AND TESTS

Microscopic Examination. 6. (*a*) A microscopic examination of the tubes shall show sufficient annealing for complete recrystallization with a uniform grain size not in excess of 0.045 mm. in average diameter, the grain size approaching as closely as possible a mean diameter of not over 0.035 mm. (Note 2).

(*b*) The determination of grain size shall be made by comparison of micrographs representing the samples with micrographs of standard specimens for which the grain size has been accurately determined. The magnification in all such micrographs shall be 75 diameters. The standard micrographs shall be taken from specimens, the grain size of which has been determined by Jeffries' method for grain size measurements as described in the Standard Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (Serial Designation: E 2) of the American Society for Testing Materials[1] at a magnification of 250 diameters. Reproductions of micrographs so prepared by the U. S. Bureau of Standards are appended hereto.

Hammering Test. 7. The tubes shall be capable of withstanding the following test without showing cracks or flaws: Pieces cut from the ends of the tubes shall be hammered flat on different elements throughout their length so that a gage set at 3 times the thickness of the metal shall pass over the tube freely throughout the flattened-part, except at such points where changes in the elements of flattening take place.

Expanding Test. 8. The tubes shall be capable of withstanding the following test without showing signs of cracking or rupture: A pin having a taper of 1½ in. per foot shall be driven into the tube until the diameter has been increased 20 per cent.

Strain Test. 9. A test specimen 6 in. in length shall withstand an immersion in an aqueous mercurous nitrate solution containing 100 g. of mercurous nitrate and 13 cc. of nitric acid (sp. gr. 1.42) per liter of solution for 15 minutes, without cracking (Note 3).

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[1] 1921 Book of A.S.T.M. Standards.

Hydrostatic Test. 10. All tubes shall withstand an internal hydrostatic pressure of 1000 lb. per sq. in. without leakage and shall show no sign of strain or cracking (Note 4).

Number of Tests. 11. Tubes shall be grouped into lots of 600 tubes or less. Two tubes shall be selected from each lot and subjected to the physical tests specified in Sections 6 to 9, inclusive.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS

Thickness. 12. No tube at its thinnest point shall be less than the thickness specified.

Length. 13. The length shall not be less but may be $\frac{1}{16}$ in. more than that ordered when measured at a temperature of 70° F.

Weight. 14. No single tube that exceeds the calculated weight by more than 5 per cent will be accepted. One cubic inch of the material is assumed to weigh 0.308 lb.

V. WORKMANSHIP AND FINISH

Workmanship. 15. The tubes shall be round, straight and of uniform thickness throughout. They shall be free from cracks, seams, slivers, scale and other surface defects both inside and outside.

Finish. 16. All tubes shall be acid cleaned after the final annealing.

VI. INSPECTION AND REJECTION

Rejection. 17. If any test specimen representing a lot fails to meet the requirements of Section 4 and Sections 6 to 8, inclusive, two additional specimens, at the option of the manufacturer, may be taken as before and submitted for check analysis or subjected to any tests in which the original specimen failed, but each of these specimens shall conform to the requirements specified.

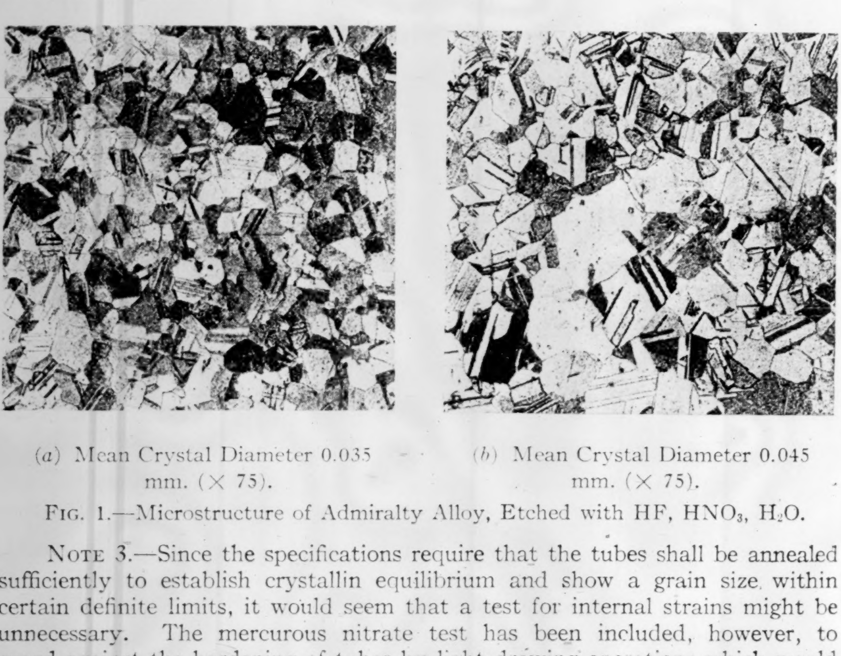
Inspection. 18. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

EXPLANATORY NOTES

NOTE 1.—The ideal composition for Admiralty metal is 70 per cent of copper, 29 per cent of zinc, and 1 per cent of tin, and better tubes will be obtained by adhering as closely as possible to this composition, particularly as to tin. It does not, therefore, seem wise to make 1 per cent of tin the minimum but rather in order to obtain as nearly 1 per cent as possible to allow some variation under 1 per cent and make the minimum limit for tin 0.90 per cent.

NOTE 2.—The so-called "Compression Test" requiring that tubes of varying sizes and thicknesses should be subjected to certain arbitrary pressures without more than 0.005 in. permanent deformation has not been included because the physical properties of the tube under compression are functions of the temperature at which it receives its final heat treatment and the metallographic examination sufficiently indicates the temper of the tube to decide whether it may be properly packed in the condenser head.

Until concrete information is available relative to the effect of grain size on corrosion, the committee points out that Section 6 *(a)* has been prepared solely for the purpose of getting a measurement of the compressibility and freedom from stress.



(a) Mean Crystal Diameter 0.035 mm. (× 75).

(b) Mean Crystal Diameter 0.045 mm. (× 75).

FIG. 1.—Microstructure of Admiralty Alloy, Etched with HF, HNO_3, H_2O.

NOTE 3.—Since the specifications require that the tubes shall be annealed sufficiently to establish crystallin equilibrium and show a grain size within certain definite limits, it would seem that a test for internal strains might be unnecessary. The mercurous nitrate test has been included, however, to guard against the hardening of tubes by light drawing operations which would not deform the crystals to an extent recognizable by microscopic examination.

NOTE 4.—Provision is made for the testing of each tube separately to 1000 lb. per sq. in. hydrostatic pressure in order to develop and make evident fractures or punctures which may have occurred in the process of manufacture. This is a 100 per cent test and it is not necessary to again test all the tubes by subjecting them to 80 lb. per sq. in. pneumatic pressure while immersed in water. Both of these tests are made to detect the same kind of faults and either if carried out according to the intent of the specifications should be sufficient. The 1000-lb. hydrostatic pressure test is the more searching and has been specified. The multiplication of tests to determine the same facts under the plea that there may be carelessness in applying one or another should not be encouraged.

TENTATIVE SPECIFICATIONS
FOR
NON-FERROUS INSECT SCREEN CLOTH[1]

Serial Designation: B 50 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Scope.

1. These specifications cover insect screen cloth woven from non-ferrous wire and intended to be used as a protection against insects or other small animals.

I. MANUFACTURE

Manufacture.

2. There shall be two classes of standard insect screen cloth depending upon the material used as follows:

(*a*) *Class A*, comprising cloth made from copper wire.

(*b*) *Class B*, comprising cloth made from a 90 copper-10 zinc alloy wire.

3. Insect screen cloth shall be manufactured in four weights or sizes of mesh as follows:

14-mesh
16-mesh
16-mesh heavy
18-mesh

4. The same quality and size of wire shall be used for both the warp and filling.

II. CHEMICAL PROPERTIES

Chemical Requirements.

5. The composition of the wire used for Class A insect screen cloth shall conform to the requirements either of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 4), or of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. H. Bassett, Secretary of Committee D-14 on Screen Wire Cloth, American Brass Co., Waterbury, Conn.

[2] 1921 Book of A.S.T.M. Standards.

6. The wire for Class B insect screen cloth shall conform to the following chemical requirements:

Copper	90.00 to 92.00 per cent
Lead, maximum	0.03 per cent
Iron, maximum	0.06 per cent
Zinc	Remainder

III. PHYSICAL PROPERTIES OF WIRE

7. The physical properties for all classes of screen wire shall be subject to agreement between the producer of the wire and the purchaser.

NOTE.—Wire for weaving insect screen cloth is usually furnished with a drawn temper. The needs of different weavers of wire cloth apparently call for difference in drawn temper and it is consequently at present impossible to give definite physical properties which would be satisfactory to the entire trade. It has, therefore, seemed better to leave this matter to specific agreement between the producers of wire and the manufacturers of wire cloth.

IV. STANDARD SIZES, WEIGHTS, DIMENSIONS, ETC.

Size of Wire. 8. (*a*) The nominal diameter of wires to be used for the various weights of standard insect screen cloth shall be in accordance with the following:

MESH	DIAMETER, IN.
14	0.0119
16	0.0113
16 (Heavy)	0.0150
18	0.0106

(*b*) The permissible variation from the nominal diameter of any of the wires specified above shall be ±0.00025 in.

9. The mesh as determined by counting the openings per linear inch for a length of one foot on any samples selected at random shall not vary from the nominal value in the warp, but an average variation of not more than ½ mesh per linear inch shall be permissible in the filling.

10. Insect screen cloth shall be furnished in rolls of approximately 100 linear feet. At least 87.5 per cent of the rolls ordered shall be in one continuous length; the remaining rolls may be in two lengths.

11. The widths of standard insect screen cloth shall be from 18 to 48 in. in multiples of 2 in. The permissible variation in over all width as measured from outside wire to outside wire shall be ±⅛ in.

V. WORKMANSHIP AND FINISH

12. The insect screen cloth shall be free from all imperfections and blemishes not consistent with best commercial practice.

VI. INSPECTION

13. (*a*) All testing and inspection, both of individual wires and completed cloth, shall be made at the place of manufacture. Tests on individual wires shall be made on samples taken before weaving and not on wires removed from finished cloth.

(*b*) The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to these specifications.

APPENDIX

The following table giving the weights of various mesh of insect screen cloth is not a part of these specifications, but is appended as a source of information for the purchaser:

MESH	APPROXIMATE WEIGHT PER 100 SQ. FT. OF INSECT SCREEN CLOTH WRAPPED AND LABELED READY FOR SHIPMENT
14	14½ lb.
16	15 "
16 (Heavy)	27¾ "
18	14 "

TENTATIVE METHOD
OF
DETERMINATION OF ZINC IN PIG LEAD[1]

Serial Designation: B 35 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

DETERMINATION OF ZINC IN PIG LEAD

Solutions Required

Nitric Acid (1 : 4).—Mix 200 cc. of HNO_3 (sp. gr. 1.42) with 800 cc. of distilled water.

Sulfuric Acid (1 : 1).—Carefully pour, with stirring, 500 cc. of H_2SO_4 (sp. gr. 1.84) into 500 cc. of distilled water.

Acidulated Hydrogen Sulfide Water.—Add 20 cc. of HCl (sp. gr. 1.19) to 1000 cc. of distilled water and saturate with hydrogen sulfide.

Ammonium Thiocyanate Solution (2-per-cent).—Dissolve 20 g. of NH_4CNS in 1000 cc. of distilled water.

Hydrochloric Acid (1 : 3).—Mix 100 cc. of HCl (sp. gr. 1.19) and 300 cc. of distilled water.

Standard Zinc Solution (0.1 mg. of zinc per cc.).—Dissolve exactly 0.1 g. of U. S. Bureau of Standards pure zinc in 5 cc. of HCl (sp. gr. 1.19) and dilute to exactly 1000 cc. with distilled water.

Potassium Ferrocyanide Solution.—Dissolve 34.8 g. of $K_4Fe(Cn)_6 \cdot 3H_2O$ in 1000 cc. of distilled water.

Method

Dissolve 222.23 g. of the sample in 1100 cc. of HNO_3 (1 : 4), using a 1300-cc. beaker. When the lead is dissolved, transfer the solution to a 2000-cc. graduated flask and add slowly 150 cc. of H_2SO_4 (1 : 1). Cool, fill the flask to the mark and then pour the solution into a clean 3000-cc. flask provided with a rubber stopper. Rinse the measuring flask with exactly 50 cc. of water, which is equivalent to the volume of lead sulfate which is present. Mix the solution thoroughly by shaking, allow the precipitate to settle and filter through a dry filter until 1800 cc. of filtrate has been obtained.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

This method is intended to supersede the present Method for the Determination of Zinc and the Method for the Determination of Manganese, appearing in the present Standard Methods of Chemical Analysis of Pig Lead (Serial Designation: B 35 - 20), 1921 Book of A.S.T.M. Standards. The tentative method, when adopted as standard, will be added to the Standard Methods B 35 - 20.

Place exactly 1800 cc. of filtrate (equivalent to a 200-g. charge) in a No. 9 porcelain evaporating dish and evaporate the solution to approximately 100 cc. Transfer the solution to a 600-cc. beaker, neutralize with ammonia, and then add 5 cc. of HCl (sp. gr. 1.19) for every 100 cc. of solution. Warm the solution and pass in a rapid current of hydrogen sulfide until it is saturated. Digest for 30 minutes on the steam bath, add an equal volume of water and again saturate with hydrogen sulfide. Filter and wash with acidulated H_2S water.

Discard the precipitate and evaporate the filtrate in glassware containing no zinc (such as Pyrex) until the volume of the solution is approximately 100 cc.

Neutralize the solution with ammonium hydroxide, add 5 g. of citric acid, and warm until the acid is dissolved. Add small portions of calcium carbonate to the hot citric acid solution until about 1 g. of calcium citrate has separated and then pass in a rapid current of H_2S as the solution is allowed to cool. Allow the solution to stand for from 2 to 4 hours, part of the time on a water bath, until the supernatant liquid is clear.

Collect the precipitate on a filter, wash with a 2-per-cent solution of ammonium thiocyanate and then dissolve the precipitate in hot dilute hydrochloric acid (1 : 3). If the solution has a reddish color (due to iron) the zinc must be reprecipitated as above. If the solution is clear, evaporate it to dryness on the steam bath, take up the residue in 3 cc. of HCl (sp. gr. 1.19) add 20 cc. of water and filter if not perfectly clear.

Transfer the solution (Note 2) to a 50-cc. Nessler jar and dilute to 45 cc. Prepare other Nessler jars containing 3 cc. of HCl (sp. gr. 1.19) definite volumes of standard zinc solution, and diluted to 45 cc. Add 5 cc. of potassium ferrocyanide solution to each jar, mix quickly, and compare the turbidities by viewing longitudinally as the jars are held over a sheet of fine print. Add more of the standard zinc solution from a burette to the jar which approximates the turbidity of the unknown most closely, until the turbidities match each other and calculate the percentage of zinc on the basis of a 200-g. sample or the aliquot portion taken.

NOTES

1. All glassware that contains zinc must be avoided and in umpire work a blank test should be carried along with the test.

2. The whole solution can be used if the lead contains no more than 0.002 per cent of zinc. If more zinc is present it is best to take such an aliquot portion of the solution as will give approximately 4 mg. of zinc and then to add enough HCl to provide 3 cc.

3. For further details concerning the turbidmetric test, consult the "Determination of Small Quantities of Zinc" by Mr. Bodansky, in the *Journal of Industrial and Engineering Chemistry*, Vol. 13, pp. 696–697 (1921).

4. The addition of calcium carbonate with the formation of a precipitate of calcium citrate serves the purpose of giving a clear filtrate, and prevents the loss of colloidal sulfide.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF ALUMINUM AND LIGHT ALUMINUM ALLOYS.[1]

Serial Designation: B 40 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

The methods of analysis listed under "Analysis of Aluminum" contemplate the analysis of aluminum containing more than 98 per cent aluminum and containing only silicon, titanium, iron, copper, carbon and traces of manganese as impurities.

Unless it is positively known that such elements as tin, antimony, zinc, lead, nickel, magnesium, sodium, nitrogen or oxygen (as aluminum oxide) are absent, the methods listed under the "Analysis of Light Aluminum Alloys" should be employed.

ANALYSIS OF ALUMINUM.

(NOT LESS THAN 98 PER CENT ALUMINUM.)

A. DETERMINATION OF NON-GRAPHITIC SILICON, GRAPHITIC SILICON, TOTAL SILICON, TITANIUM AND IRON.

DETERMINATION OF NON-GRAPHITIC SILICON.

SOLUTIONS REQUIRED.

"*Acid Mixture.*"—1200 cc. of H_2SO_4 (25-per-cent by volume), 600 cc. HCl (sp. gr. 1.20) and 200 cc. HNO_3 (sp. gr. 1.42).

25-per-cent Sulfuric Acid.—Pour 250 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, and dilute to 1000 cc.

METHOD.

Dissolve 1 g. of the well-mixed sample in 35 cc. of the acid mixture in a covered flat-bottomed porcelain dish or casserole. When the drillings are completely dissolved, boil the solution to complete expulsion of HNO_3 and HCl and heat until copious fumes of H_2SO_4 have been given off for five minutes. Cool and take up the residue with 10 cc. of 25-per-cent H_2SO_4 and 100 cc. of water. Warm to complete solution of the sulfates and filter on an ashless filter paper. Wash the residue with hot water until free from sulfates, ignite in a platinum crucible and weigh. Treat the ash with HF and a few drops of 25-per-cent H_2SO_4, carefully evaporate, ignite and again weigh. The difference in the two weights multiplied by the factor 46.93 represents the percentage of non-graphitic silicon.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1924, to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

DETERMINATION OF GRAPHITIC SILICON.

See "Determination of Non-Graphitic Silicon."

The non-volatile residue obtained above, especially if dark colored, may contain graphitic silicon. Treat the non-volatile residue with 5 cc. HNO_3, 5 cc. HF, carefully evaporate, and add 2 or 3 drops of 25-per-cent H_2SO_4 toward the end of the evaporation. Ignite and weigh. Reserve the residue for the "Determination of Titanium." The loss in weight multiplied by 100 represents the percentage of graphitic silicon.

DETERMINATION OF TOTAL SILICON.

The total silicon is represented by the sum of the percentages of non-graphitic and graphitic silicon.

NOTES.

Blanks should be carried along with all reagents and the proper corrections made

Graphitic silicon is only slightly and slowly oxidized to silica by the solution or ignition treatments, and to the extent in which it is not oxidized, it resists the action of HF and H_2SO_4. Graphitic silicon is, however, readily attacked and volatilized by a mixture of HNO_3 and HF. On account of the possibility of slight oxidation of graphitic silicon by the treatments involved in the method, the latter may not be absolutely exact, but it is the best that has been devised.

DETERMINATION OF TITANIUM.

APPARATUS AND SOLUTIONS REQUIRED.

Nessler tubes or some form of colorimeter.

Hydrogen Peroxide U. S. P.—This reagent must be free from HF.

Standard Titanium Solution.—This solution is best prepared and standardized as follows:[1]

"Potassium titanium fluoride, K_2TiF_6, best serves as the starting point for the preparation of the standard solution. A quantity of this is recrystallized from boiling water one or more times, dried, and preserved in a glass-stoppered bottle. Enough of it to make 0.5 to 1 liter of the standard sulfate solution is put into a platinum dish and evaporated several times with strong sulfuric acid without bringing to dryness, till the fluorine is completely expelled. The residue is then taken up with water containing enough sulfuric acid to make at least 5 per cent of the latter when fully diluted. Two 50 to 100-cc. portions of the prepared solution are then further diluted, boiled, and precipitated with ammonia. The precipitates are collected on paper, washed with hot water till free from alkali, ignited moist in the filter, blasted, and weighed. Duplicates should agree almost exactly. From the weights found, the strength of the standard is calculated and the result affixed to the bottle containing it. The stopper of the bottle should be coated with vaseline and the needed quantities of solution should be withdrawn by a pipette, never poured. In a solution so prepared there is not enough alkali sulfate to weaken the color when peroxidized."

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[1] W. F. Hillebrand, "The Analysis of Silicate and Carbonate Rocks," *Bulletin No. 700*, U. S. Geological Survey, p. 157.

METHOD.

See "Determination of Graphitic Silicon".

Fuse the non-volatile residue remaining after the graphitic silicon determination in a small amount of $K_2S_2O_7$, take up in a little 5-per-cent H_2SO_4 and add to the filtrate and washings from the silicon determination. Evaporate the solution to approximately 100 cc., and treat with 5 cc. H_2SO_4 (sp. gr. 1.84) and 3 g. of iron-free zinc. Heat until the zinc is nearly dissolved and the reduction of copper is complete. Decant the solution into another beaker, wash the zinc and copper with hot water and continue the evaporation of the solution to approximately 75 cc. Cool and transfer to a 100-cc. Nessler's comparison tube, add 5 cc. of 3-per-cent H_2O_2 and dilute to the 100-cc. mark. In another tube, place 88 cc. H_2O, 5 cc. of H_2SO_4 (sp. gr. 1.84) and cool. Add 5 cc. of 3-per-cent H_2O_2 and then from a burette add the standard titanium solution until the colors match. Reserve the tested solution for the determination of iron. The volume of the standard solution required multiplied by 100 times its titre represents the percentage of titanium in the sample.

NOTES.

The filtrate and washings from the Silicon Determination should ordinarily be colorless. If light yellow owing to iron, the standard comparison solution should be brought to the same tint with ferric sulfate solution before adding the hydrogen peroxide.

In case the amount of titanium is high the solution may be diluted to a definite volume and aliquot portions taken for the colorimetric test.

DETERMINATION OF IRON.

SOLUTIONS REQUIRED.

Potassium Permanganate Solution (10-per-cent).—Dissolve 10 g. of $KMnO_4$ in distilled water and dilute to 100 cc.

Dilute Sulfuric Acid for Reduction.—Mix 50 cc. of H_2SO_4 (sp. gr. 1.84) and 1000 cc. of distilled water. This solution is used boiling hot.

Standard Potassium Permanganate Solution.—Dissolve 1 g. of $KMnO_4$ in 1000 cc. H_2O, and allow to stand for several days in a glass-stoppered bottle in a dark closet. Filter the solution through prepared asbestos and standardize against 0.1000-g. portions of pure sodium oxalate. Each cubic centimeter is equivalent to approximately 0.0018 g. of iron.

METHOD.

See "Determination of Titanium."

Transfer the solution used in the "Determination of Titanium" from the Nessler tube to a 400-cc. beaker, add 10-per-cent $KMnO_4$ solution to a good permanent pink tint and pass the solution through the reductor. Wash the beaker and reductor with 150 cc. of the H_2SO_4 for reduction and then with 100 cc. of distilled water. Titrate with the standard $KMnO_4$ solution.

The results of the titration should be corrected by a "blank" determination made on 100 cc. of a 7-per-cent H_2SO_4 solution which has been carried through as in the titanium and iron determinations, not omitting the treatment with iron-free zinc, hydrogen peroxide, and permanganate preliminary to the actual reduction. About 0.5 cc. of the permanganate solution will be required to give a permanent color to the blank.

Calculate the apparent percentage of iron. To obtain the true percentage, multiply the percentage of titanium by 1.161 and subtract.

NOTES.

For description and further details of use of reductor see "Chemical Analysis of Iron," by A. A. Blair, or "Quantitative Chemical Analysis," by H. P. Talbot.

Air should never be allowed to enter the body of the reductor.

Titanium is reduced to the trivalent condition in the reduction process and afterwards oxidized to the quadrivalent condition by the permanganate. There is a slight tendency toward oxidation in the receiver, but this may be disregarded in the small amounts of titanium ordinarily involved.

In case titanium is present and iron alone is to be determined proceed as follows: Place the H_2SO_4 solution of the sample in a 250-cc. flask, dilute to 100 cc. containing 2.5 cc. H_2SO_4 (sp. gr. 1.84) and treat with H_2S for 30 minutes in the cold and 15 minutes while warmed. If sulfides appear, filter and gas the filtrate 10 minutes more.

Add 15 cc. H_2SO_4 (1 : 1) and boil vigorously until H_2S is expelled and the volume reduced to 50 cc. Fill the flask with distilled water, transfer to a beaker, and titrate with $KMnO_4$ solution.

DETERMINATION OF COPPER.

(a) *Electrolytic Method.*

APPARATUS FOR ELECTROLYSIS.

See the "Determination of Copper by the Electrolytic Method" in the Standard Methods of Chemical Analysis of Manganese Bronze (Serial Designation : B 27) of the American Society for Testing Materials.[1]

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and dilute to 1000 cc.

METHOD.

Dissolve 10 g. of the sample in 100 cc. of dilute H_2SO_4 (1 : 1). When action has ceased add 25 cc. of HNO_3 (sp. gr. 1.42) and boil until oxides of nitrogen have been expelled. Filter into the tall form of beaker used in electrolysis and wash the residue with hot water. Dilute to 400 cc. and electrolyze. Use a weighed sand-blasted cathode and a current of from 3 to 5 amperes at approximately 10 volts. When the solution is colorless and 1 cc. of the solution gives no copper test with H_2S water on a porcelain plate, remove the solution from the electrodes quickly without interrupting the current. Quickly rinse the cathode in distilled water and then dip it in two successive baths of alcohol. Shake off the excess alcohol and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

NOTES.

The electrolytic method is preferred for the determination of copper no matter what the percentage.

It is not anticipated that the aluminum will contain tin. In case tin has been found it will be preferable to precipitate with hydrogen sulfide as in the optional method. The sulfides are then to be dissolved, digested in HNO_3 (1 : 1), the metastannic acid filtered off and the electrolysis then carried out.

A staining of the anode indicates the presence of lead or manganese.

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[1] 1921 Book of **A.S.T.M. Standards.**

(*b*) *Iodide Method.* (Optional.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1:1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and dilute to 1000 cc.

Wash Solution.—Saturate 500 cc. of H_2SO_4 (1 : 99), with H_2S.

Nitric Acid (1 : 1).—Pour 500 cc. of HNO_3 (sp. gr. 1.42) into distilled water, cool and dilute to 1000 cc.

Potassium Iodide Solution.—Dissolve 30 g. of KI in water and dilute to 100 cc.

Sodium Thiosulfate Solution.—Dissolve 19 g. of $Na_2S_2O_3.5H_2O$ in distilled water and dilute to one liter. After aging for 1 week or more in a glass-stoppered bottle, standardize against 0.1 g. portions of C.P. copper or suitable material of known copper content, carried through the operations of the method described below. One cubic centimeter should correspond to approximately 0.005 g. of copper.

Starch Solution.—Grind 0.5 g. arrow-root starch in a mortar with a little water to a smooth paste and pour into 250 cc. of boiling water. Boil 3 minutes, cool, and allow to settle. The clear solution should be employed and it must be prepared frequently.

METHOD.

Place 10 g. of the sample in a covered porcelain dish or casserole and dissolve in 80 cc. of dilute H_2SO_4 (1 : 1). When solution is complete, add 5 cc. of HNO_3 (sp. gr. 1.42) and evaporate the solution until dense fumes of H_2SO_4 are given off. Cool the solution and add 200 cc. of distilled water. Boil until the sulfates are in solution, filter and wash with hot water. Treat with hydrogen sulfide until the solution is cold. Filter, wash with the hydrogen sulfide wash solution and dissolve the precipitate in the smallest possible amount of hot HNO_3 (1 : 1). Digest the HNO_3 solution at near boiling for one hour unless the absence of tin is assured. Filter if necessary and evaporate to a syrupy consistency. Transfer the HNO_3 solution of the copper to a 250-cc. flask add 5 cc. of strong bromine water and boil until all bromine and oxides of nitrogen are expelled. Add a slight excess of NH_4OH, add then $HC_2H_3O_2$ in slight excess. Cool, add 10 cc. of KI solution and titrate at once with the $Na_2S_2O_3$ solution until the free iodine is nearly removed, then add 5 cc. of starch solution and continue the titration cautiously until the color due to free iodine has entirely vanished. The volume of thiosulfate employed multiplied by ten times its copper titre represents the percentage of copper in the sample.

NOTE.

Copper, when present in small amounts, may also be determined by potassium cyanide titration. See Standard Methods of Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (Serial Designation: B 18) of the American Society for Testing Materials.[1]

DETERMINATION OF MANGANESE.

(*a*) *Persulfate Method.* (For samples containing under 1.5 per cent of Manganese.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool, and dilute to 1000 cc.

Silver Nitrate.—Dissolve 1.33 g. of $AgNO_3$ in 1000 cc. of distilled water.

Stock Sodium Arsenite Solution.—To 15 g. of arsenious oxide (As_2O_3) in a 300-cc. Erlenmeyer flask, add 45 g. of Na_2CO_3 and 150 cc. of distilled water. Heat the flask and contents on the steam bath until the As_2O_3 is dissolved. Cool the solution, filter and make up to 1000 cc. with distilled water.

Standard Sodium Arsenite Solution.—Mix 200 cc. of the stock sodium arsenite solution with 2500 cc. of distilled water, and standardize by the method described below against a steel or iron of known manganese content. One cubic centimeter of this solution should be equivalent to approximately 0.00050 g. of manganese.

Ammonium Persulfate.—Dissolve 6 g. of ammonium persulfate in 100 cc. of distilled water. (This solution should be made up as needed as it deteriorates rapidly.)

METHOD.

In a 250-cc. Erlenmeyer flask, dissolve 0.5 g. of the sample in 25 cc. of H_2SO_4 (1 : 1) by warming and adding a drop or two of HNO_3 (sp. gr. 1.42) occasionally until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 cc. with boiling hot water, remove the flask from the flame, add 20 cc. of $AgNO_3$ solution, and then 30 cc. of the persulfate solution. Let the solution stand on the steam bath until it has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color.

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[1] 1921 Book of A.S.T.M. Standards.

NOTES.

Large amounts (above 0.01 g. of manganese per 100 cc. of solution) of permanganic acid are unstable; the method can, however, be used with satisfaction for alloys containing high percentages of manganese by decreasing the size of the sample.

The ammonium persulfate must be tested for its strength. A good grade should contain about 95 per cent of $(NH_4)_2 S_2O_8$; some lots contain no more than 25 per cent of the salt.

(*b*) *Bismuthate Method.* (For samples containing less than 1.50 per cent manganese.) (Optional.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and dilute to 1000 cc.

Nitric Acid (1 : 3).—Pour 250 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

Dilute Nitric Acid (3-per-cent).—Pour 30 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

Standard Permanganate Solution.—Dissolve 1 g. of $KMnO_4$ in 1000 cc. of distilled water. Allow it to stand for at least one week and then filter through purified asbestos. Standardize against 0.1 g. portions of pure sodium oxalate. One cubic centimeter of this solution should be equal to approximately 0.00035 g. of manganese.

Standard Ferrous Ammonium Sulfate Solution.—Dissolve 12.4 g. of ferrous ammonium sulfate crystals in 950 cc. distilled water, and add 50 cc. of H_2SO_4 (sp. gr. 1.84).

METHOD.

In a 250-cc. Erlenmeyer flask dissolve 0.5 g. of the sample in 10 cc. of H_2SO_4 (1 : 1), adding a drop or two of HNO_3 (sp. gr. 1.42) occasionally.

When solution is complete heat to expel all oxides of nitrogen and cool. Dilute with 50 cc. of HNO_3 (1 : 3) and add 0.5 g. sodium bismuthate. Heat for a few minutes until the purple color has disappeared with or without the precipitation of manganese dioxide. Add a little ferrous ammonium sulfate solution until the solution becomes clear and boil until the oxides of nitrogen are expelled. Cool, add an excess of sodium bismuthate and agitate for a few minutes. Add 50 cc. of 3-per-cent HNO_3 and filter through an alundum crucible or an asbestos pad. Wash with 50 cc. of 3-per-cent HNO_3. Add from a pipette or a burette 10 to 50 cc. (depending on the amount of permanganic acid) of ferrous ammonium sulfate solution and titrate with the $KMnO_4$ solution.

In exactly the same manner carry through a blank determination using the same amounts of H_2SO_4, HNO_3, and sodium bismuthate as was done with the regular sample. Finally add the exact volume of ferrous ammonium sulfate solution employed and titrate with the $KMnO_4$ solution.

The difference between the volumes required in the two titrations represents the manganese in the sample, and the percentage is found by multiplying this volume by 200 times the manganese titre of the permanganate solution.

NOTES.

Large amounts (above 0.01 g. of manganese per 100 cc. of solution) of permanganic acid are unstable; the method can be used with satisfaction for alloys containing high percentages of manganese by decreasing the size of the sample.

The filtrate from the bismuthate must be perfectly clear, as the least particle of bismuthate carried into the filtrate will vitiate the results.

The solution must be cold at time of filtration and titration.

Instead of employing the method of reducing permanganic acid by means of standardized ferrous ammonium sulfate solution and titrating the excess of the reagent, it is possible to reduce the permanganic acid by standard sodium-arsenite solution. See "Determination of Manganese by the Persulfate Method."

DETERMINATION OF CARBON.

SOLUTIONS REQUIRED.

Copper-Potassium Chloride Solution.—Dissolve 300 g. of $CuCl_2.2KCl.2H_2O$ in water, dilute to 1000 cc., filter through ignited asbestos and preserve in a glass-stoppered bottle.

METHOD.

Place 3 g. of the sample in a 400-cc. beaker, add 200 cc. of the $CuCl_2.2KCl$ solution and 10 cc. of HCl (sp. gr. 1.20). Stir the solution constantly with a glass rod for some minutes and then occasionally until solution is complete. The solution may be warmed slightly but never above 50° C., and continuous mechanical stirring hastens the solution. When solution is complete, add a little ignited asbestos, wash down the sides of the beaker with a little acidulated $CuCl_2.2KCl$ solution and allow to settle. Filter on ignited asbestos in a Gooch crucible or, preferably, on a platinum boat.[1] Transfer the carbonaceous matter completely with dilute acidulated $CuCl_2.2KCl$ solution and scrub the sides of the beaker. Finally wash with distilled water until chlorides are absent and then dry at 100° C. When dry, burn in a combustion tube through which is passed a current of oxygen freed from all organic compounds. The post train should contain a tube containing pumice soaked in sulfuric acid saturated with chromic acid to oxidize and retain any sulfur dioxide and a tube containing $CuSO_4$ dehydrated at 200° C. to catch any traces of HCl, in addition to the ordinary driers, carbon dioxide absorbers and protectors. The weight of carbon dioxide × 0.27273 represents the carbon in the sample.

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[1] A. A. Blair, "The Chemical Analysis of Iron," 8th edition, Lippincott and Co., pp. 152–154.

ANALYSIS OF LIGHT ALUMINUM ALLOYS.

A. DETERMINATION OF SILICON (NON-GRAPHITIC, GRAPHITIC AND TOTAL), TITANIUM AND IRON.

DETERMINATION OF SILICON.

(NON-GRAPHITIC, GRAPHITIC AND TOTAL SILICON.)

Proceed as described under "Determination of Silicon" in Aluminum.

NOTE.

In case lead sulfate is present (as evidenced by a white crystallin precipitate quickly settling after stirring to the bottom of the casserole) the filtered precipitate must be washed free from the sulfate with an $HN_4C_2H_3O_2$ wash solution made up as follows: Take 20 cc. NH_4OH (sp. gr. 0.90) add 20 cc. of distilled water and make slightly acid with glacial acetic acid. The final washing must be made with hot water.

DETERMINATION OF TITANIUM.

(a) *In the absence of nickel.*

METHOD.

Proceed as described under "Determination of Titanium" in Aluminum.

NOTE.

Vanadium, which interferes in the test, should not be encountered in this class of material. Its presence would be betrayed by an "off" reddish-brown cast in the peroxidized solution.

(b) *In the presence of nickel.*

METHOD.

Dissolve 1 g. of the sample as described under "Determination of Tin and Antimony" below. If the nitric acid solution of the sodium hydroxide insoluble is not clear it must be filtered, the residue burned in platinum, fused with a little $K_2S_2O_7$, dissolved in a little 5-per-cent H_2SO_4 and added to the nitric acid filtrate. Dilute the nitric acid solution to 200 cc., treat with NH_4OH (sp. gr. 0.90) until ammoniacal, boil 3 minutes, filter and wash. Dissolve the precipitate in hot dilute H_2SO_4 (25-per-cent) keeping the volume below 80 cc., cool and proceed with the colorimetric test as described under "Determination of Titanium" in Aluminum.

NOTES.

The above method provides for the color interference of copper and nickel when they are present in large amounts.

Vanadium (see Notes above) and other elements which would cause color interferences are not apt to occur in this class of material.

DETERMINATION OF IRON.

METHOD.

Proceed as described under "Determination of Iron" in Aluminum.

NOTES.

In case the alloy contains high percentages of copper, lead, tin or antimony it is preferable to treat the combined filtrate and washings from the silicon determination with H_2S and filter off and wash the sulfates. The solution should then be boiled free from hydrogen sulfide, treated with 10-per-cent $KMnO_4$ solution to a pink tint and then reduced as directed.

Reducible elements other than iron and titanium must be absent. Such elements are chromium, vanadium, molybdenum, tungsten and uranium, and they ordinarily will not be found in this class of material.

For the determination of iron in the presence of titanium see Notes under "Determination of Iron" in Aluminum.

DETERMINATION OF ANTIMONY, TIN, LEAD AND COPPER.

PRELIMINARY SEPARATION.

SOLUTIONS REQUIRED.

Sodium Hydroxide Solution (25-per-cent).—Dissolve 250 g. of NaOH in distilled water and dilute to 1000 cc. If a sediment forms on standing, decant the solution and filter through an asbestos pad. The NaOH must be entirely free from organic matter.

Nitric Acid (1 : 1).—Pour 500 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

METHOD.

Dissolve 5 g. of the sample in a covered porcelain dish of suitable size in 125 cc. of (25-per-cent) NaOH solution. When solution is complete dilute with 100 cc of distilled water, decant off the clear solution and wash the residue well with hot dilute NaOH solution

(2-per-cent). Treat the filtrate and washings with H_2S. If no precipitate appears, zinc is absent. In case a precipitate appears, zinc must be determined in a fresh sample as described further. Unfold the wet paper containing the NaOH insoluble and wash the residue back into the original vessel. Replace the paper in the funnel and pour 20 cc. of hot HNO_3 (1 : 1) over the paper and allow it to filter into the original vessel. Boil the residue until action ceases and oxides of nitrogen are expelled. Add 50 cc. of hot distilled water and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on an ashless paper, being careful to keep the solution hot throughout the process of filtration, and receiving the filtrate in a 200-cc. beaker of the tall type used in electrolysis. Wash with boiling hot water. Retain the filtrate and washings for subsequent use in the copper and lead determinations and treat the residue as described under "Determination of Antimony."

NOTES.

Antimony will be quantitatively recovered with the tin provided it does not exceed one-fifth its amount. In the rare case of high antimony evaporate the nitric acid solution of the NaOH insoluble to dryness, bake at 105° C., take up in hot 10-per-cent by volume nitric acid, and proceed with the filtration and washing.

The metastannic acid precipitate will not contain enough copper to make a recovery worth while in ordinary work. As iron is determined in a separate portion and does not interfere in the determinations of antimony and tin, it may also be disregarded.

DETERMINATION OF ANTIMONY

SOLUTIONS REQUIRED.

Standard Permanganate Solution.—The solution prepared as under "Determination of Iron" may be employed. It must be standardized against weighed 0.05-g. portions of pure antimony or suitable material of known antimony content carried through the regular procedure after solution in acid and treatment in the Kjeldahl flask.

METHOD.

See "Preliminary Separation."

Transfer the filter containing metastannic acid and antimony oxide to a 500-cc. Kjeldahl flask, add 10 to 12 cc. H_2SO_4 (sp. gr. 1.84) and 3 to 5 g. Na_2SO_4. Heat until all organic matter is decomposed. Dilute, when cool, with 20 cc. of water. Add 0.5 g. Na_2SO_3 and boil until all SO_2 is expelled from the flask. Dilute to about 250 cc., add 20 cc. of HCl (sp. gr. 1.20) cool to 10° C. and titrate with the $KMnO_4$ solution to the first definite shade of pink. Reserve the solution for the "Determination of Tin."

DETERMINATION OF TIN.

SOLUTIONS REQUIRED.

Standard Iodine Solution.—Dissolve 10.7 g. of iodine in 50 cc. of water containing 20 g. of KI in solution, and dilute to 1000 cc. *when the iodine is completely in solution.* Standardize against pure tin by the method described below.

Starch Solution.—Prepare as described under "Determination of Copper, Iodide Method."

METHOD.

See "Determination of Antimony."

Transfer the solution used in "Determination of Antimony" to a 450-cc. Erlenmeyer flask, add an excess of powdered antimony and 50 cc. of HCl (sp. gr. 1.20). Attach a reflux condenser and boil for 15 minutes on a hot plate. Cool in a current of CO_2, add 5 cc. of starch solution, and without disconnecting the stream of CO_2, titrate with the iodine solution to the blue end point.

DETERMINATION OF COPPER AND LEAD SIMULTANEOUSLY.

BY THE

ELECTROLYTIC METHOD.

APPARATUS REQUIRED.

See "Determination of Copper" under "Analysis of Aluminum."

METHOD.

See "Preliminary Separation."

Dilute the filtrate and washings from the "Preliminary Separation" to about 150 cc. with distilled water and electrolyze, using weighed sand-blasted cathode and anode. Cover with a pair of split watch glasses and use a current of from 1.25 to 1.5 amperes, at approximately 10 volts for each solution. After about one hour the lead will have been entirely deposited on the anode as PbO_2; without interrupting the current add to the electrolyte 3 to 4 cc. of H_2SO_4 (sp. gr. 1.84), wash down the cover glasses, electrodes and sides of the beaker and continue the electrolysis for 15 minutes. If no darkening of the newly-exposed anode surface can be detected and if a few drops of H_2S water added to 1 cc. of the electrolyte on a porcelain plate gives no coloration the electrolysis is complete. In this case, remove the solution from the electrodes quickly without interrupting the current. Rinse the electrodes in quick succession with distilled water and then twice with alcohol. Reserve the electrolyte and water washings for the nickel and magnesium determinations. Dry the anode at 210° C. for thirty minutes. Weigh as PbO_2, using the factor for lead 0.8643 instead of the theoretical value. Shake off the excess alcohol from the cathode and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

NOTE.

The electrolyte and water washings may be diluted to 500 cc. and one 250-cc. portion taken for the "Determination of Nickel" and the other for the "Determination of Magnesium" as directed further. If the alloy contains copper and no tin, antimony or lead the electrolytic method given under "Determination of Copper" in Aluminum may be employed.

DETERMINATION OF LEAD AS SULFATE.

(OPTIONAL.)

SOLUTIONS REQUIRED.

"Lead Acid."—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 1800 cc. of distilled water. Dissolve 1 g. of lead acetate C.P. in 300 cc. of distilled water and add this to the hot solution, stirring meanwhile. Let stand at least 24 hours and siphon through a thick asbestos filter.

Dilute Alcohol for Washing.—Mix equal parts of denatured alcohol and distilled water.

METHOD.

See "Preliminary Separation."

To the combined filtrate and washings from the "Preliminary Separation" add 120 cc. of lead acid, and evaporate until copious fumes of H_2SO_4 are evolved. Cool, add 105 cc. of distilled water to dissolve the salts and to make the concentration the same as in the lead acid, heat to boiling, and allow to cool and settle for 5 hours, or over night if convenient. Filter on a weighed porcelain Gooch crucible and wash with lead acid. Set the filtrate and washings aside for the "Determination of Copper by the Iodide Method." Continue the washing and wash out the lead acid with dilute alcohol. Set the Gooch crucible inside a porcelain crucible, dry and ignite for 5 minutes at the full heat of a Tirrill burner. Cool and weigh as $PbSO_4$, which contains 68.32 per cent lead.

DETERMINATION OF COPPER
BY THE
IODIDE METHOD.
(OPTIONAL.)

METHOD.

See "Determination of Lead as Sulfate."

Dilute the reserved filtrate and washings from the "Determination of Lead as Sulfate" with an equal volume of water, treat with H_2S and proceed as directed in "Determination of Copper by the Iodide Method" under "Analysis of Aluminum."

DETERMINATION OF NICKEL
BY THE
DIMETHYLGLYOXIME METHOD.

SOLUTIONS REQUIRED.

Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool, and dilute to 1000 cc.

Hydrogen Sulfide Wash Water.—Add 10 cc. of H_2SO_4 (sp. gr. 1.84) to 1000 cc. of distilled water and saturate with H_2S.

Tartaric Acid Solution (20-per-cent).—Dissolve 20 g. of tartaric acid in distilled water, dilute to 100 cc. and filter if necessary.

Dimethylglyoxime Solution (1-per-cent).—Dissolve 10 g. of the reagent in 1000 cc. of 95-per-cent alcohol.

METHOD.

Dissolve 1 g. of the sample in 25 cc. of H_2SO_4 (1 : 1) as directed in "Determination of Manganese by the Persulfate Method." After oxides of nitrogen have been expelled add 14 cc. NH_4OH in order to bring down the acidity to approximately 5 cc. H_2SO_4 (sp. gr. 1.84) per 100 cc. of solution. Treat with hydrogen sulfide. Filter off the sulfides, wash with hydrogen sulfide wash water and boil the filtrate until H_2S is expelled. Add a few crystals of $(NH_4)_2S_2O_8$ and boil thoroughly to destroy sulfur and oxidize iron. Add 20 cc. of tartaric acid solution and make slightly ammoniacal. If no precipitate appears add HCl (sp. gr. 1.20) to slight acidity. If a precipitate appears, dissolve in HCl add 10 cc. of tartaric acid and again make ammoniacal, repeating the operation, if necessary, to get a clear solution. To the weakly acid solution add dimethylglyoxime in such an amount that the ratio of the reagent to nickel is at least 4 : 1. Heat the solution to boiling, and make slightly ammoniacal. Allow to digest while cooling for two hours. Collect on a weighed Gooch crucible and wash thoroughly with hot water. Dry for forty-five minutes at 110 to 120° C. and weigh. The nickel dimethylglyoxime contains 20.32 per cent of nickel.

NOTES.

In case copper and lead have been determined electrolytically, nickel may be determined in one 250-cc. portion of the electrolyte and washings (see Notes), starting with the $(NH_4)_2S_2O_8$ treatment to oxidize iron and then proceeding as directed in the method above.

Nickel may be precipitated by glyoxime, filtered, dissolved in nitric acid, made ammoniacal and titrated with cyanide solution according to Frevert's method.[1]

DETERMINATION OF MAGNESIUM.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 1).—Pour 500 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Sulfuric Acid Wash Water.—Saturate 500 cc. of a 1-per-cent H_2SO_4 solution with H_2S.

Ammonium Sulfide Wash.—Take 10 cc. of NH_4OH, dilute to 500 cc., add 10 g. NH_4Cl and saturate with H_2S.

Microcosmic Salt Solution.—Prepare a clear saturated solution as required.

Ammoniacal Wash Solution.—Dissolve 50 g. of NH_4NO_3 in distilled water, add 50 cc. NH_4OH (sp. gr. 0.90) dilute to 1000 cc. and filter if necessary.

METHOD.

Dissolve 10 g. of the sample and wash the residue as directed under the "Preliminary Separation Determination of Antimony, Tin, Lead and Copper." Dissolve the residue in 10 cc. hot HCl (1 : 1) using a little HNO_3 if necessary. If the hydrogen sulfide group of metals are present, neutralize with NH_4OH, make weakly acid with HCl, dilute to 100 cc., heat and precipitate with hydrogen sulfide. Filter off the sulfides and wash with the H_2SO_4 wash water. To this filtrate or to the HCl solution if no H_2S treatment was required, add 5 cc. HCl (sp. gr. 1.20) make slightly ammoniacal and precipitate with H_2S. Let the solution stand for about two hours at a temperature of approximately 40° C. (at the side of the steam bath). Filter and wash with the $(NH_4)_2S$ wash. Acidify the filtrate with HCl, boil off H_2S, add $(NH_4)_2S_2O_8$ and boil to destroy sulfur if necessary. Add 1 g. of tartaric acid and 30 cc. of microcosmic salt solution. Cool, and add NH_4OH (sp. gr. 0.90) drop by drop while stirring vigorously until a crystallin precipitate begins to form. Continue the very slow addition of NH_4OH with stirring until a precipitate no longer forms and then add one-tenth the volume of NH_4OH (sp. gr. 0.90) and let stand over night. Filter and wash with cold ammoniacal wash solution. Ignite slowly under oxidizing conditions in a tared porcelain or platinum crucible and finally heat over the blast lamp or its equivalent. Weigh as $Mg_2P_2O_7$. The weight multiplied by 0.2185 represents magnesium.

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[1] A. A. Blair, "The Chemical Analysis of Iron," 8th Edition, Lippincott and Co., pp. 182–183.

NOTE.

In case copper and lead were determined electrolytically one reserved portion of the electrolyte and washings (see Notes) may be used for the determination of magnesium, starting in with the addition of 5 cc. HCl (sp. gr. 1.20) and the precipitation of the $(NH_4)_2S$ group.

DETERMINATION OF MANGANESE.

(*a*) *Persulfate or Bismuthate Method.* (For samples containing under 1.50 per cent manganese.)

Proceed as directed in "Determination of Manganese" under "Analysis of Aluminum."

(*b*) *Nitric Acid and Potassium Chlorate Method.*[1] (For samples containing over 1.50 per cent manganese.)

SOLUTIONS REQUIRED.

Hydrochloric Acid (1 : 1).—Mix 500 cc. of HCl (sp. gr. 1.20) and 500 cc. of distilled water.

Sulfurous Acid.—Pass SO_2 from a cylinder into 500 cc. of cold distilled water until saturated.

Bromine Water.—Place 20 to 30 cc. of liquid bromine in a 500-cc. bottle, fill with cold distilled water, and shake thoroughly. *Avoid any contact with the skin.*

Dilute Hydrochloric Acid (1 : 3.)—Pour 250 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Sodium-Ammonium Phosphate Solution.—Prepare this solution as needed by dissolving 1 part of the salt in 6 parts of cold water and filtering.

Ammonium Nitrate Solution.—Dissolve 100 g. of NH_4NO_3 in distilled water, make slightly ammoniacal, dilute to 1000 cc. and filter if necessary.

METHOD.

In a 250-cc. Erlenmeyer flask dissolve 1 g. of the sample in 30 cc. of. HCl (1 : 1). When solution is complete add 25 cc. HNO_3 (sp. gr.

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[1] A. A. Blair, "The Chemical Analysis of Iron," 8th Edition, J. B. Lippincott and Co., pp. 108–115

1.42) and evaporate until the solution is almost syrupy. Add 50 cc. of HNO_3 (sp. gr. 1.42) and 5 g. $KClO_3$. Heat the solution to boiling either on the hot plate or on a tripod with a thin piece of sheet asbestos, about 1 in. (25 mm.) in diameter, on the center of the wire gauze. Boil the solution 15 minutes, remove from the heat, add 50 cc. HNO_3 (sp. gr. 1.42) and 5 g. $KClO_3$ and boil 15 minutes longer or until yellowish fumes are no longer given off. Cool the solution rapidly in cold water and filter through asbestos. Wash two or three times with HNO_3 (sp. gr. 1.42) (free from oxides of nitrogen which dissolve the dioxide).

Transfer the dioxide with the asbestos filter to the beaker in which the precipitation was made. Pour from 10 to 40 cc. of strong sulfurous acid through the filtering apparatus into the beaker. As soon as the precipitate has dissolved, filter from the asbestos into a 150-cc. beaker, wash with hot water, and add 5 cc. HCl (sp. gr. 1.20). Heat to expulsion of SO_2, add bromine water until the solution is strongly colored with it, and boil off all excess bromine. Add NH_4OH in slight excess, boil for a few minutes, and filter into a 600-cc. beaker. Wash with hot water, remove and reserve the filtrate, and dissolve the precipitate in dilute HCl (1 : 3), allowing the solution to run back into the beaker in which the precipitation was made. Wash the filter with hot water. Boil the solution for 10 minutes to drive off any chlorine and reprecipitate by NH_4OH as before, filter into the reserved filtrate and repeat the solution, precipitation and filtration, allowing all the filtrates from the $Fe(OH)_3$ to run into the 600-cc. beaker. Acidulate this solution, which will be about 300 or 400 cc. in volume, with acetic acid, heat to boiling and treat with H_2S for 10 minutes. Filter, wash with a little dilute acetic acid saturated with hydrogen sulfide and boil off the hydrogen sulfide after adding 5 cc. of HCl (sp. gr. 1.20). Add from 5 to 20 cc. of a clear filtered solution of microcosmic salt, heat to boiling, and add NH_4OH drop by drop with constant stirring. When the precipitate begins to form, stop the addition of NH_4OH and stir until the precipitate becomes crystallin. When this change occurs add one more drop of ammonia; the additional precipitate formed will be curdy, but a few seconds stirring will change it to the silky crystallin condition. Continue the addition of NH_4OH in exactly the same manner until the precipitate is all down and further additions of NH_4OH fail to change the silky appearance. Add a dozen drops of NH_4OH in excess and cool the beaker in ice water. Filter the precipitate on an asbestos filter, wash with the cold NH_4NO_3 solution until the filtrate gives no reaction for HCl.

Dry, ignite and weigh as $Mn_2P_2O_7$ which contains 38.69 per cent manganese.

NOTES.

The Ford method is recommended only where extreme accuracy is desired; otherwise use the persulfate or bismuthate methods.

If a cylinder of SO_2 is not available, hydrogen peroxide will serve equally well for the solution of the hydrated manganese dioxide.

DETERMINATION OF ZINC.

(a) *Samples containing up to 3 per cent of zinc.*

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 1).—Pour 500 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Acid Wash Water.—Pour 10 cc. of H_2SO_4 (sp. gr. 1.84) into 1000 cc. of distilled water and saturate with H_2S.

Formic Acid Mixture.—Treat 400 cc. of formic acid with 60 cc. of NH_4OH (sp. gr. 0.90) and dilute to 2000 cc.

Formic Acid Wash Water.—Pour 25 cc. of formic acid mixture into 1000 cc. of distilled water and saturate with H_2S.

Dilute Hydrochloric Acid (1 : 10).—Pour 100 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Bromine Water.—See "Determination of Manganese, Nitric Acid and Potassium Chlorate Method."

METHOD.

Dissolve 1 g. of the sample in a covered 400-cc. beaker in 25 cc. of dilute HCl (1 : 1), with the addition of 1 cc. of HNO_3 (sp. gr. 1.42) toward the end of the reaction. Boil to expel oxides of nitrogen and dilute to 200 cc. Precipitate the H_2S group, filter and wash with acid wash water. Boil thoroughly to expel H_2S, cool, and add 5 g. of citric acid crystals. Neutralize with NH_4OH, using methyl orange as an indicator and then add 25 cc. of the formic acid mixture. Dilute to 300 cc., heat nearly to boiling and pass in H_2S until the solution is cold. Filter and wash with the formic acid wash water. Dissolve the zinc sulfide off the filter with warm dilute HCl (1 : 10) and wash the filter with hot water. Boil the solution to expel H_2S. Cool, add 1 g. of citric acid crystals, neutralize with NH_4OH, using methyl orange as an indicator and then add 20 cc. of the formic acid mixture. Dilute to 200 cc. and proceed as before through the filtration on an ashless paper and washing of the sulfide. Dissolve the precipitate with hot dilute HCl, and transfer the solution to a weighed platinum or porcelain dish or crucible. Add a few drops of H_2SO_4 (sp. gr. 1.84) and evaporate the solution until copious fumes escape. If the solution is not clear and colorless, cool, add a few cubic centimeters of HNO_3 (sp. gr. 1.42) and again evaporate the solution until fumes of H_2SO_4 come off freely. Repeat the treatment with HNO_3 if necessary, until the organic matter is destroyed, and the solution is colorless. Remove the excess of H_2SO_4 by heating the dish cautiously, and finally heat at a temperature just below dull redness. Weigh as $ZnSO_4$, which contains 40.49 per cent of zinc.

NOTE.

The use of a sodium hydroxide solution of the turnings is not recommended for the determination of zinc on account of uncertainty as to the completeness of the solution of the zinc in all cases.

(*b*) *Samples containing over 3 per cent of zinc.*[1]

SOLUTIONS REQUIRED.

Ferrous Sulfate Solution.—Dissolve 3 g. of $FeSO_4 . 7H_2O$ in distilled water, add 10 cc. of HCl (sp. gr. 1.20) and dilute to 1000 cc.

Ferrocyanide Solution.—Dissolve 44 g. of K_4FeCN_6 and 0.3 g. of K_3FeCN_6 in distilled water, dilute to 1000 cc. and age six weeks before standardization as follows: Dissolve 6 g. of zinc of known content in 40 cc. of HCl (sp. gr. 1.20) in a 2-liter flask. Cool and make up to the mark. Take 100-cc. portions, add 20 cc. of HCl (1 : 1) and add 13 cc. of NH_4OH (sp. gr. 0.90) and proceed with the titration as directed below.

METHOD.

Proceed as in the previous method until the first zinc sulfide precipitate has been obtained. Return the paper and precipitate to the original beaker and add 20 cc. of HCl (1 : 1). When the sulfide has dissolved, filter off the paper together with some sulfur and possibly a little nickel sulfide. Boil the solution containing the zinc to expel H_2S, cool, and wash down. Add 13 cc. of NH_4OH (sp. gr. 0.90) and if the solution is not alkaline, add NH_4OH carefully until it is. Make the solution barely acid again with HCl (1 : 1) and add 3 cc. of HCl (sp. gr. 1.20) in excess. Add 1 cc. of $FeSO_4$ solution, dilute nearly to 200 cc., heat almost to boiling and titrate with the K_4FeCN_6 solution. The end point is a sharp change in the color of the solution from a turquoise blue to a "pea green" and with several more drops to a "creamy yellow."

NOTE.

The end point occurs a little sooner than the one with uranium nitrate, and is easier to use, as the change is seen directly in the solution.

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[1] Method of F. G. Breyer, 8th International Congress of Applied Chemistry 1, 162; see also "Analysis of Copper," G. L. Heath, McGraw-Hill Book Co., pp. 250, 251.

DETERMINATION OF CARBON.

Determine carbon as described under "Analysis of Aluminum."

DETERMINATION OF SODIUM.

SOLUTIONS REQUIRED.

Dilute Nitric Acid (1 : 2).—Pour 250 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 750 cc.

Saturated Ammonium Carbonate Solution.—Small quantities made up as required.

METHOD.

Dissolve 5 g. of the sample in a porcelain dish in 100 cc. of dilute HNO_3 (1 : 2) by continued digestion at 50 to 60° C. When solution is complete, evaporate the solution to dryness and heat on a sand bath for several hours to complete decomposition of aluminum nitrate, but without melting any sodium nitrate formed. Cool the residue, take it up in boiling distilled water, filter and wash thoroughly. Treat the water extract with saturated $(NH_4)_2CO_3$ solution, heat to boiling and filter if a precipitate forms. Evaporate the clear filtrate in a weighed platinum dish, treat the residue with sufficient H_2SO_4 to convert the nitrate to sulfate, continue the evaporation and finally heat at 300 to 400° C. to complete expulsion of H_2SO_4. Weigh as Na_2SO_4. A blank should be carried through all operations and the proper correction applied.

DETERMINATION OF NITROGEN.

SOLUTIONS REQUIRED.

Sodium Hydroxide Solution (10-per-cent).—Dissolve 100 g. of NaOH in distilled water, dilute to 1000 cc. and filter through asbestos if the solution develops a sediment upon standing.

Approximate N/10 Sulfuric Acid Solution.—Pour 2.8 cc. of H_2SO_4 (sp. gr. 1.84) into 1000 cc. of distilled water and standardize by any standard method.

Approximate N/10 Sodium Hydroxide Solution.—Dissolve 4.5 g. of NaOH in distilled water and dilute to 1000 cc. This solution should be standardized against the standard acid solution.

METHOD.

Place 3 to 4 g. of the sample in a Kjeldahl flask fitted with a two-hole stopper carrying a separatory funnel and a trap connected with a condenser as in a Kjeldahl determination of nitrogen. Add 400 cc.

of the NaOH solution through the separatory funnel, and allow the generated gas to bubble through 50 cc. of N/10 sulfuric acid solution. When the reaction has ceased, boil the alkaline solution to expel all ammonia. Finally titrate the acid with N/10 sodium hydroxide in the usual manner and calculate nitrogen.

DETERMINATION OF ALUMINUM AND ALUMINUM OXIDE.

SOLUTIONS REQUIRED.

Sodium Hydroxide Solution (10-per-cent).—Dissolve 100 g. of NaOH in distilled water and dilute to 1000 cc. If a sediment forms on standing, decant the solution and filter through an asbestos pad.

Sodium Carbonate Solution.—Dissolve 36 g. of Na_2CO_3 in distilled water, dilute to 1000 cc., and filter if necessary.

Barium Chloride Solution.—Dissolve 90 g. of $BaCl_2.2H_2O$ in distilled water, dilute to 1000 cc., and filter if necessary.

Dilute Hydrochloric Acid.—Dilute 500 cc. of HCl (sp. gr. 1.20) with 500 cc. of water.

Methyl Red Indicator.—Dissolve 0.02 g. of the acid in 100 cc. of distilled water.

Ammonium Chloride Wash Solution.—Dissolve 50 g. of NH_4Cl in distilled water, make sure the solution is just alkaline to methyl red, dilute to 1000 cc. and filter if necessary.

Dilute Nitric Acid (1 : 1).—Dilute 500 cc. of HNO_3 (sp. gr. 1.42) with 500 cc. of distilled water.

Acid Wash Water.—Add 5 cc. of H_2SO_4 (sp. gr. 1.84) to 500 cc. of water and saturate with H_2S.

PRELIMINARY TREATMENT.

Place 2 g. of the sample in a suitable porcelain dish, add 60 cc. of the NaOH solution (10-per-cent), cover with a glass, and cool in water if the reaction proceeds too violently. When violent action ceases, wash the cover-glass and sides of the vessel, replace the glass and warm on a sand bath or steam-box until reaction ceases. These operations should be carried on expeditiously. Filter and wash the residue with hot NaOH solution (10-per-cent). Reserve the residue and treat the filtrate and washings as below.

(a) *Determination of Aluminum.*

Cool the filtrate and washings to room temperature, dilute to exactly 500 cc. and mix thoroughly. Transfer pipetted 50-cc. portions to 600-cc. beakers, add 10 cc. of HCl (sp.gr. 1. 20), place on water bath and evaporate to dryness. When dry, continue the heating for one hour more. Take up the residue in cold distilled water, transfer to a flask and add a mixture of 50 cc. of the Na_2CO_3 solution and 50 cc. of the $BaCl_2$ solution. Shake thoroughly and allow to settle. Filter, wash with cold water, and then transfer the precipitate to the original flask by piercing the paper and washing down with boiling water, finally with dilute HCl, adding enough to dissolve the precipitate and avoiding mechanical loss. Evaporate the solution to one-third volume, add a few drops of methyl red and then NH_4OH (sp. gr. 0.90) until the indicator just turns yellow. Boil for three minutes, filter and wash with warm 5-per-cent NH_4Cl solution. Bring the precipitate back into the beaker as before, dissolving all $Al(OH)_3$ on the paper and evaporate the solution to dryness. Drench with a little HCl (sp. gr. 1.20) add hot water and warm until salts are in solution. Filter in case a residue is present, reprecipitate $Al(OH)_3$ and wash as above. Place the wet paper and contents in a tared crucible (with cover and preferably of platinum), dry, ignite carefully in an oxidizing atmosphere and finally cover and blast strongly. Weigh as Al_2O_3 and calculate aluminum.

NOTES.

This method is a modification of the method proposed by J. G. Rhodin, Faraday Society Trans., *14*, (1918–19) pp. 135–7 and presupposes complete solubility of aluminum and insolubility of aluminum oxide in a 10-per-cent solution of NaOH.

It is important that the "50-cc." pipette deliver exactly one-tenth of the "500-cc." volume.

Two precipitations with NH_4OH are necessary to eliminate barium and the intervening evaporation to dryness is desirable in case silica is present.

(*b*) *Determination of Aluminum Oxide.*

See "Preliminary Separation."

Transfer the residue insoluble in NaOH solution (10-per-cent) to a small flask and treat the paper with hot dilute HNO_3 (1 : 1). When solution of the residue is complete, dilute to 100 cc., neutralize with NaOH solution (10-per-cent), add 3 cc. HCl (sp. gr. 1.20) and treat with hydrogen sulfide. Filter, wash the sulfides with acid wash water and boil the filtrate and washings until H_2S is expelled, using a few crystals of $K_2S_2O_8$ if sulfur separates. Pour the hot solution slowly and with stirring into 50 cc. of boiling hot NaOH solution (10-per-cent). Filter and wash with a little hot NaOH solution (10-per-cent).

In case the precipitate is large, dissolve it and reprecipitate. Acidify the NaOH filtrate or filtrates with HCl (sp. gr. 1.20) and precipitate $Al(OH)_3$ as described in (*a*) above. A second precipitation should be carried out in case the precipitate is large, and always in accurate work. Ignite, weigh as Al_2O_3 and report as such.

TENTATIVE SPECIFICATIONS
FOR
HYDRATED LIME FOR STRUCTURAL PURPOSES.[1]

Serial Designation: C 6 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1917; Revised, 1919, 1921, 1922, 1923.

1. These specifications cover two classes of hydrated lime: namely, masons' hydrate and finishing hydrate.

Uses. 2. (*a*) Masons' hydrated lime may be used for scratch or brown coat of plaster, for stucco, for mortars, and for addition to portland-cement concrete.

(*b*) Finishing hydrated lime may be used for any of the purposes enumerated in Paragraph (*a*) for masons' hydrated lime, and in addition it may be used as an ingredient of the final or white coat of plaster.

I. REQUIREMENTS.

Masons' Hydrate. 3. Masons' hydrated lime shall conform to the chemical and physical requirements herein specified except that for plasticity, specified in Section 9.

Finishing Hydrate. 4. Finishing hydrated lime shall conform to all chemical and physical requirements herein specified including that for plasticity, specified in Section 9.

Chemical Properties. 5. (*a*) *Carbon Dioxide.*—Carbon dioxide in the sample shall not exceed 5 per cent if the sample is taken at the place of manufacture, or 7 per cent if the sample is taken at any other place. The percentages in both cases are based on the non-volatile portion.

(*b*) *Calcium and Magnesium Oxides.*—Calcium and magnesium oxides shall constitute not less than 95 per cent of the non-volatile portion.

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[1] These tentative specifications are intended to supersede the Standard Specifications for Hydrated Lime. The Standard Specifications, which were last published under the Serial Designation: C 6 - 15, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. P. Brown, Secretary of Committee C-7 on Lime, National Lime Association, 918 G Street, N.W., Washington, D. C.

6. A 100-g. sample shall leave a residue of not more than 0.5 per cent on a No. 30 sieve, and not more than 15 per cent on a No. 200 sieve. **Fineness.**

7. A pat of mortar, covered with a skim coat of neat paste, shall be subjected to the action of steam. If the steam has no visible effect on the pat, the sample shall be reported as being "sound." If the pat disintegrates, the sample shall be reported "unsound," and the shipment rejected. If the sample cracks, pops, or shows other minor defects, it shall not be reported as either sound or unsound, but its behavior shall be noted. **Constancy of Volume.**

8. When tested in the form of a mortar composed of 1 part by weight of the sample and 3 parts by weight of standard Ottawa sand, the mortar shall show a tensile strength of not less than 15 lb. per sq. in. at 7 days. **Tensile Strength.**

9. Finishing hydrated lime shall have a plasticity figure of not less than 200, when tested in accordance with Section 15. **Plasticity.**

III. METHODS OF TEST.

10. The chemical analysis of the hydrated lime shall be made in accordance with the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (Serial Designation: C 25 – 22 T) of the American Society for Testing Materials.[1] **Chemical Analysis.**

11. Fineness[2] of hydrated lime shall be determined as follows: **Fineness.**

One hundred grams of the sample as received shall be placed on a No. 30 sieve which shall be nested above a No. 200 sieve. The material shall be washed by means of a stream of water from a faucet (Note 1). The washing shall be continued until the water coming through the sieve is clear. The residue upon the No. 30 sieve shall be dried to constant weight in an atmosphere free from carbon dioxide in a drying oven whose temperature is maintained between 100 and 120° C. The weight of this residue shall be calculated as percentage of the original sample.

The material which has passed the No. 30 sieve and remained on the No. 200 sieve shall be then washed through the latter as above described. The residue on this sieve shall be treated in the same manner as described above for that retained on the No. 30 sieve and the percentage retained added to the percentage of residue on the No. 30 sieve. The sum of these two shall be reported as the percentage of residue on the No. 200 sieve.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 715 (1922).

[2] Specifications for U. S. Standard Sieve Series in U. S. Bureau of Standards *Circular No. 74*.

NOTE 1.—A small piece of rubber tubing attached to a water faucet will be found convenient. The velocity of the stream of water may be increased by pinching the tubing, but the velocity should not be sufficient to cause any danger of splashing the sample over the sides of the sieve.

Constancy of Volume.

12. Constancy of volume shall be determined as follows:

To 20 g. of the sample, 100 g. of standard Ottawa sand shall be added, mixed thoroughly and enough water added to the mixture to make a good plastic mortar of a rather dry consistency. This shall be spread out on a clean glass plate to form a layer of about 0.5 cm. ($\frac{1}{4}$ in.) thick by about 10 cm. (4 in.) square. The pat shall be of even thickness throughout and not tapering at the edges. If the mortar is too dry to work well, more water may be added. This pat shall be placed in a closet for 24 hours to set. The temperature in the closet shall be between 18 and 24° C. (65 and 75° F.) and there shall be free circulation of air in the closet but no direct draft shall be permitted to hit the pat. At the end of 24 hours the pat shall be removed from the closet and soaked in water until a film of water stands unabsorbed on the surface of the pat. The pat shall be examined carefully for cracks. If any are present, too much water has been used in making the pat and it should be discarded and a new one made.

Twenty grams of the sample shall be mixed with enough water to form a thick cream. This shall be spread out in a thin layer on the surface of the pat. It shall be allowed to stand for 15 minutes to permit possible air bubbles to form. It shall be troweled to an even surface, making this skim coat as thin as possible without allowing the sand to show through. The pat shall be put back in the closet for another 24 hours for the skim coat to set. It shall be examined carefully to make sure there are no cracks or pops. A vessel shall be provided partially filled with cold water and having a perforated cover. The pat shall be suspended in this vessel in such a way that the water can boil without touching it. The water shall be brought gradually to boiling and kept boiling gently for 5 hours, the pat being surrounded by steam during this time. The water shall then be permitted to cool for at least 12 hours before the cover is removed from the vessel. The pat shall then be removed and examined for cracking, popping, or disintegration.

Consistency.

13. Consistency of lime putty shall be determined by the use of a modified form of the Vicat apparatus, a plunger 12.5 mm. in diameter and weighing 30 g., being substituted for the usual 300-g. plunger. This plunger is conveniently made of 12.5-mm. aluminum tubing with square closed end.

The lime shall be made to a stiff putty by mixing with water and the putty soaked over night in a suitable container adapted to prevent the evaporation of moisture. The soaked putty shall be placed in the rubber ring used with the Vicat apparatus, with the rubber ring resting on a glass plate.

The initial reading shall be taken with the bottom of the plunger set in contact with the surface of the sample. The plunger shall then be released and the final reading taken after 30 seconds. The consistency of the putty is "standard" when the plunger penetrates 20 mm. into the mass.

If the plunger does not penetrate 20 mm., the putty shall be removed from the mold and mixed with a little more water until a penetration of 20 mm. is obtained.

If the plunger penetrates more than 20 mm., additions of lime shall not be made, but the material shall be discarded and a new mixture prepared. In preparing the lime for soaking, "snap" tests should be made to avoid obtaining too thin a putty.

For measuring consistency of lime mortar, the same plunger shall be loaded to weigh 100 g. The same procedure shall be followed as detailed above, and the consistency of the mortar is "standard" when the plunger penetrates 20 mm. into the mass.

Tensile Strength.

14. In a suitable vessel, 200 g. of the sample shall be mixed with 600 g. of standard Ottawa sand. Sufficient water shall be added to bring the mixture to standard consistency as defined above with a permissible variation of ± 5 mm.

The mixture having been brought to the proper consistency, it shall be molded to form six briquettes. These briquettes shall be of the form and size specified in Section 50 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.[1] After the molds have been filled with mortar, the whole shall be placed on edge in a damp closet and allowed to stand over night. They shall then be removed from the damp closet and be exposed to room atmosphere for 24 hours longer. The briquettes shall then be removed from the molds and shall be stored on edge in room atmosphere in such a way that the air can circulate freely around each briquette until ready for test.

For measuring the tensile strength of lime mortars, the machine used shall be direct acting, that is, there shall be no levers introduced between the load and the specimen. The cut-off mechanism which stops the application of load shall be automatic and instantaneous. The machine shall be regulated to apply the load at the rate of 15 lb. per minute. The maximum capacity of the machine shall be not less than 50 nor more than 100 lb., and it shall be sensitive to within 1 per cent at any load.

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[1] 1921 Book of A.S.T.M. Standards.

Plasticity. 15. The plasticity shall be determined by means of the apparatus shown in Fig. 1 as follows: Three hundred grams of the sample shall be mixed with enough water to form a thick putty. After aging for not less than 16 nor more than 24 hours, this putty shall be adjusted to standard consistency, as defined in Section 13, with a permissible variation of ± 5 mm.

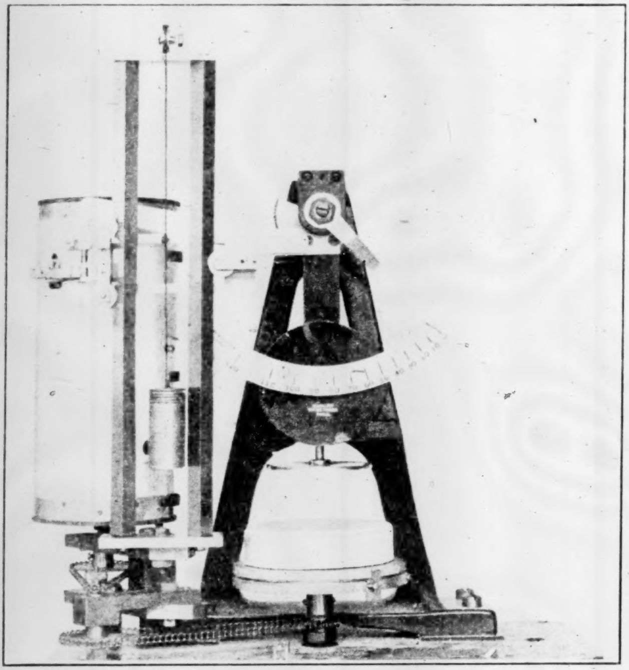

FIG. 1.—Emley Plasticimeter.

Constants of the Machine:

Absorption of porcelain base plate.—20 to 25 per cent.
Dimension of base plate.—1 in. in thickness by 4 in. in diameter.
Dimensions of disk.—$\frac{1}{32}$ in. in thickness by 3 in. in diameter.
Speed of vertical shaft.—One revolution in 6 minutes, 40 seconds.
Upward Movement of base plate.—$\frac{1}{13}$ in. per revolution.
Torque on disk when bob reading is 100.—14,400 g.c.m.

The mold[1] shall be placed on a porcelain base plate and filled with the paste, and struck off level. The mold shall be removed by raising it vertically without distorting the paste. The base plate and paste shall be placed in the instrument (Fig. 1) and the carriage turned up by hand until the surface of the paste comes in contact with the disk and there is some torsion set up as indicated by a slight movement of the dial.

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[1] This mold is the same as that specified in Section 38 of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials, 1921 Book of A.S.T.M. Standards.

The carriage shall be thrown into gear and the motor started. It is essential that the motor shall be started exactly sixty seconds after the first portion of paste has been put in the mold. The time when the first portion of paste is put in the mold shall be recorded as zero time—the motor therefore is started at one minute.

Care shall be taken to protect the specimen from drafts, throughout the test.

The scale reading shall be observed and recorded every minute until the test is complete.

The test shall be considered complete when (*a*) the force equals 100 as shown on the scale; (*b*) any reading is less than the one before; or (*c*) the scale reading has remained constant for two consecutive observations (one minute) and the specimen has either visibly ruptured or broken loose from the base plate.

The time and the scale reading at the end of the experiment shall be noted. The time, in minutes, elapsed since zero time shall be called T and the scale reading (indicating the force) F.

The plasticity figure, P, shall be calculated from the formula:

$$P = \sqrt{F^2 + (10\,T)^2}.$$

IV. SAMPLING, INSPECTION, REJECTION, ETC.

Sampling, Retesting, Packing, Marking.

16. The sampling, retesting, packing and marking shall be conducted in accordance with the Tentative Methods of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products (Serial Designation: C 50 - 23 T) of the American Society for Testing Materials.[1]

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[1] See p. 636.

TENTATIVE SPECIFICATIONS
FOR
CONCRETE AGGREGATES[1]

Serial Designation: C 33 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1921; REVISED, 1923

FINE AGGREGATE

Fine Aggregate. 1. Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains, free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances.

Grading. 2. Fine aggregate shall preferably be graded from fine to coarse, with the coarser particles predominating, within the following limits:

Passing $\frac{3}{8}$-in. sieve		100 per cent
Passing No. 4 sieve		85 "
Passing No. 50 sieve	not more than	30 "
Weight removed by decantation test	not more than	3 "

The sieves shall conform to the requirements specified in the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (Serial Designation: C 41) of the American Society for Testing Materials.[2]

Strength in Concrete. 3. The fine aggregate shall be tested in combination with the coarse aggregate and the cement with which it is to be used and in the proportions, including water, in which they are to be used on the work, in accordance with the requirements specified in Section 6. In case the test provided in Section 6 shows the strengths specified therein, the fine aggregate shall be considered acceptable.

Mortar Strength. 4. With the approval and consent of the engineer, the following requirements may be substituted:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. C. Pearson, Secretary of Committee C-9 on Concrete and Concrete Aggregates, U. S. Bureau of Standards, Washington, D. C.

[2] A.S.T.M. Standards Adopted in 1922.

(*a*) Mortar briquettes, cylinders or prisms, consisting of one part by weight of portland cement and three parts by weight[1] of fine aggregate, mixed and tested in accordance with the methods described in the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials,[2] shall show a tensile or compressive strength at the age of 7 and 28 days not less than that of 1:3 standard Ottawa sand mortar of the same consistency made with the same cement.

NOTE.—In testing aggregates, care should be exercised to avoid the removal of any coating on the grains which may affect the strength; bank sand should not be dried before being made into mortar, but should contain natural moisture. The percentage of moisture may be determined upon a separate sample and the weight of the sand used in the test corrected for the moisture content.

(*b*) Upon failure to meet this requirement, the proportion of cement in the concrete mixture shall be increased or the proportions of cement, fine aggregate, coarse aggregate and water changed in such a way as to produce the strength specified in Section 6.

Colorimetric Test.

5. No fine aggregate showing a color darker than the standard color when tested in accordance with the Standard Method of Test for Organic Impurities in Sands for Concrete (Serial Designation: C 40) of the American Society for Testing Materials[3] shall be used unless the strength requirement of Sections 4 or 6 is fulfilled.

Concrete Tests.

6. The grade of concrete required with its compressive strength in pounds per square inch shall be specified by the engineer. The concrete materials, including cement, fine aggregate, coarse aggregate and water, mixed in the proportions in which they are to be used in the work, and tested in accordance with the standard methods of test, shall at 28 days develop a strength of not less than that specified for the grade of concrete required. Upon failure to meet this requirement, the proportion of cement in the concrete mix shall be increased or the proportions of cement, fine aggregate, coarse aggregate and water shall be changed in such a way as to produce the specified strength.

COARSE AGGREGATE

Coarse Aggregate.

7. Coarse aggregate shall consist of crushed stone, gravel, air-cooled blast-furnace slag, or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated pieces free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter.

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[1] When approved by the engineer, these proportions may be by volume, assuming 1 cu. ft. of cement to weigh 94 lb.

[2] 1921 Book of A.S.T.M. Standards.

[3] A.S.T.M. Standards Adopted in 1922.

Quality. 8. In the case of blast-furnace slag, the weight per cubic foot shall not be less than 65 lb. per cu. ft. for use in concrete structures not subject to abrasion, and not less than 70 lb. per cu. ft. for use in concrete floor or road construction.

Grading of Coarse Aggregate. 9. (*a*) Coarse aggregate shall be well graded from fine to coarse within the following limits.[1]

Passing .... in. sieve (maximum size)............. 95 per cent
Passing .... in. sieve (intermediate size)........ .... to .... per cent

Not more than 15 per cent shall pass the No. 4 sieve; not more than 5 per cent shall pass the No. 8 sieve.

(*b*) The maximum size of coarse aggregate shall be either designated by the engineer or indicated on the plans.

NOTE.—The grading as above specified is intended to secure uniformity of aggregate, but will be governed by local conditions. The following table indicates desirable gradings, in percentages, for coarse aggregate for certain maximum sizes:

Maximum Size of Aggregate, in.	Square Openings, in.							Per Cent Passing No. 4 Sieve, not more than	Per Cent Passing No. 8 Sieve, not more than
	3	2½	2	1½	1	¾	½		
3	95	..	..	40–75	..	..	..	15	5
2½	..	95	..	..	..	..	..	15	5
2	..	..	95	..	40–75	..	..	15	5
1½	..	..	..	95	..	40–75	..	15	5
1	..	..	..	..	95	..	40–75	15	5
¾	..	..	..	..	..	95	..	15	5

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[1] When there are several suitable aggregates available, a thorough investigation of the relative economy of each for producing concrete of the desired strength is advisable, especially for work of considerable magnitude.

TENTATIVE SPECIFICATIONS

FOR

GYPSUM.[1]

Serial Designation: C 22 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1919; REVISED, 1920, 1921, 1922, 1923.

I. MATERIALS AND STANDARDS.

Testing.

1. The chemical and physical properties of gypsum shall be determined in accordance with the Standard Methods of Testing Gypsum and Gypsum Products (Serial Designation: C 26) of the American Society for Testing Materials.[2]

Definition.

2. (*a*) Pure gypsum is calcium sulfate combined in crystallin form with two molecules of water.

(*b*) Its chemical formula is $CaSO_4 \cdot 2H_2O$.

(*c*) No material may be considered gypsum within the meaning of these specifications which contains less than 64.5 per cent by weight of $CaSO_4 \cdot 2H_2O$.

Forms and Sizes.

3. Gypsum may be marketed in any of the following forms and sizes:

(*a*) *Run-of-Mine.*—The form in which it comes from the mine or quarry.

(*b*) *Crushed.*—Run-of-mine gypsum further reduced so that all of it will pass through a 2-in. (50.8 mm.) ring, and not less than 10 per cent shall be retained on a No. 3 sieve.

(*c*) *Crushed Gypsum, Sized.*—Shall all pass a No. 3 sieve, and not less than 10 per cent shall be retained on a No. 8 sieve.

(*d*) *Ground.*—Crushed gypsum further reduced to sizes suitable for specific uses. Ground gypsum may be marketed in any of the following sizes:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

[2] A.S.T.M. Standards Adopted in 1923.

No. 1.—Material of this size shall all pass a 14-mesh sieve, and not less than 85 per cent of it shall pass a 100-mesh sieve.

No. 2.—Material of this size shall all pass a 14-mesh sieve, and not less than 60 nor more than 85 per cent of it shall pass a 100-mesh sieve.

No. 3.—Material of this size shall all pass an 8-mesh sieve, and not less than 40 nor more than 60 per cent of it shall pass a 100-mesh sieve.

No. 4.—Material of this size shall all pass a 100-mesh sieve.

Chemical Properties.

4. The chemical composition, within the limits prescribed by Section 2, shall be a matter of contract.

II. SAMPLING.

Sampling from Bulk.

5. When gypsum is shipped in bulk, samples of about 5 lb. (2.25 kg.) each shall be taken at regular intervals during the complete loading or unloading of the carrier, in such a way as to accumulate at least 200 lb. (90 kg.) of material, and to represent correctly the percentages of both the coarse particles and the fines in the shipment. This shall be broken so that it will all pass a 1-in. (25-mm.) ring, thoroughly mixed, and reduced by quartering to provide not less than a 1-lb. (0.5-kg.) sample for the laboratory.

Sampling from Packages.

6. When gypsum is shipped in packages, at least 3 per cent of the packages shall be sampled. Samples shall be taken from both the surface and the center of the packages. These samples shall then be broken, mixed, and quartered as directed above.

Laboratory Samples.

7. All laboratory samples shall be placed immediately in an air-tight container and shipped to the laboratory for test.

III. PACKING AND MARKING.

Packing and Marking.

8. (*a*) Gypsum may be shipped either in packages or in bulk.

(*b*) When shipped in packages for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Form and size of material;
Chemical analysis of the material, giving the minimum percentages of CaO and SO_3;
Net weight of package.

(*c*) When shipped in bulk, a card containing the required information shall be conspicuously placed in the carrier.

IV. INSPECTION AND REJECTION.

Inspection. 9. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection. 10. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing. 11. Claims for rehearing shall be valid only if made within 20 working days from receipt of notice of specific cause for rejection.

TENTATIVE SPECIFICATIONS
FOR
GYPSUM PARTITION TILE OR BLOCK[1]

Serial Designation: C 52 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Definition. 1. Gypsum partition tile or block is a building unit used for non-bearing construction in the interior of buildings.

Composition. 2. Gypsum partition tile or block shall consist of hydrated calcined gypsum with or without an aggregate.

Form. 3. Gypsum partition tile or block shall be rectangular in shape and shall have true surfaces and straight and square edges and corners. They may be solid or cored (hollow), and the cores may be either circular, elliptical or rectangular in shape, provided the sectional members of the tile or blocks are not less than the thickness specified in Section 6.

Cored (hollow) partition tile or block 2, 2½, 3, 4, and 5 in. in thickness shall have single rows of core spaces; tile or block 6 and 8 in. in thickness shall have at least two rows of core spaces. The core spaces shall be symmetrically spaced and so located as to result in the most economical and even distribution of the material.

NOTE.—This requirement is not intended to exclude gypsum partition tile or block of special shape which will fulfill the remaining requirements of these specifications.

Thickness. 4. Gypsum partition tile or block shall be of a nominal thickness of 2 in., 2½ in., 3 in., 4 in., 5 in., 6 in. or 8 in.

NOTE.—A split 3-in. or 4-in. cored (hollow) gypsum tile or block is used for furring purposes.

Core Spaces. 5. (*a*) *Circular Core Spaces.*—The cross-sectional dimensions of gypsum partition tile or block with circular core spaces shall conform to the following:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

THICKNESS OF TILE OR BLOCK, IN.	SIDE SHELL THICKNESS, IN.		EDGE SHELL THICKNESS, IN.
	DESIRED	MINIMUM	MINIMUM
2	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
$2\frac{1}{2}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
3	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
4	$\frac{7}{8}$	$\frac{3}{4}$	$1\frac{1}{4}$
5	$1\frac{3}{16}$	$1\frac{1}{16}$	1
6	..	..	$\frac{3}{4}$
8	..	..	$\frac{1}{2}$

The side shell thickness of 6-in. tile or block shall be not less than $\frac{1}{2}$ in., and the sum of the widths of the two side shells plus the width of the center vertical web shall be not less than 2 in.

The side shell thickness of 8-in. tile or block shall be not less than $\frac{5}{8}$ in., and the sum of the widths of the two side shells plus the center vertical web shall be not less than $2\frac{1}{2}$ in.

(*b*) *Elliptical or Rectangular Core Spaces.*—The cross-sectional dimensions of gypsum partition tile or block with elliptical or rectangular core spaces shall be such as to provide for a shell thickness, at the thinnest point, of not less than 15 per cent of the maximum height of the adjacent core space, and in no case shall the shell thickness be less than the following:

THICKNESS OF TILE OR BLOCK, IN.	MINIMUM SHELL THICKNESS, IN.
2	$\frac{9}{16}$
$2\frac{1}{2}$	$\frac{9}{16}$
3	$\frac{11}{16}$
4	$\frac{13}{16}$
5	$1\frac{1}{8}$
6	..
8	..

The side shell thickness of 6-in. tile or block shall be not less than $\frac{11}{16}$ in., and the sum of the widths of the two side shells plus the width of the center vertical web shall be not less than $2\frac{3}{4}$ in.

The side shell thickness of 8-in. tile or block shall be not less than $\frac{13}{16}$ in., and the sum of the widths of the two side shells plus the width of the center vertical web shall be not less than $3\frac{1}{4}$ in.

(*c*) *Height of Core Spaces.*—The height of core spaces shall not be greater than 30 per cent of the height of the tile or block.

Dimensions.

6. (*a*) Gypsum partition tile or block shall be of any convenient length and height, but in general it shall not exceed 30 in. in length and 12 in. in height. In no case shall such tile or block be of such dimension as to be more than 3 sq. ft. in area nor be more than 60 lb. in

weight. The thickness of the tile or block shall be uniform throughout and within the limits specified in Paragraph (*b*).

(*b*) *Thickness of Tile or Blocks.*—Gypsum partition tile or block shall conform to the specified thickness with the following permissible variations:

NOMINAL SIZE OF TILE OR BLOCK, IN.	MINIMUM THICKNESS, IN.	MAXIMUM THICKNESS, IN.
2	2	2¼
2½	2⅜	2¾
3	2⅞	3¼
4	3⅞	4¼
5	4⅞	5¼
6	5¾	6¼
8	7¾	8¼

(*c*) *Dimension Determinations.*—Over-all dimensions shall be measured from opposite face to opposite face of the gypsum partition tile or block, the greatest measurement observed being taken as the dimension.

Sectional dimensions shall be taken 1 in. in from the ends of the gypsum partition tile or block, the least measurement observed being taken as the dimension.

Shell dimensions shall be measured from the surface of the core space to the normal surface of the gypsum partition tile or block inside the scoring.

Strength. 7. (*a*) The compressive strength of gypsum partition tile or block, dried to constant weight, and uniformly loaded upon the bearing area (one edge), shall be not less than 90 lb. per sq. in. for the average of five specimens tested, provided no specimen of the five tested shows a compressive strength of less than 75 lb. per sq. in.

(*b*) Gypsum partition tile or block, when completely saturated, shall have an ultimate compressive strength of not less than 33⅓ per cent of the strengths required for such tile or block when dried to constant weight.

Scoring. 8. The scoring upon gypsum partition tile or block shall be of such a nature as to not materially reduce the shell thickness.

Sampling. 9. At least one per cent of the number of gypsum partition tile or block in a shipment, but in no case less than ten tile or blocks, shall be so selected as to be representative of the shipment. Twenty-five per cent of such selected tile or block, but in no case less than ten individual tile or blocks, shall constitute a sample for test purposes. In case a shipment consists of more than one car or carrier load, a sample shall be selected from each car or carrier.

10. When gypsum partition tile or block are shipped for resale, the manufacturer's "Brand" name shall be shown upon each tile or block. **Marking.**

11. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers. **Inspection.**

12. Any rejection shall be based upon failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee. The notice of rejection shall contain a specific statement of the respects in which the tile or block have failed to meet the requirements of these specifications. **Rejection.**

13. Claims for rehearing shall be valid only if made within twenty working days from receipt of notice of specific cause for rejection. **Rehearing.**

TENTATIVE METHODS OF SAMPLING, INSPECTION, PACKING AND MARKING OF QUICKLIME AND LIME PRODUCTS.[1]

Serial Designation: C 50 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

I. METHOD OF SAMPLING.

A. General.

General.

1. (*a*) All samples shall be taken in triplicate and immediately sealed in air-tight, moisture-proof containers.

(*b*) One sample shall be immediately delivered to the consignee; one sample shall be delivered to the consignor if requested within ten days from the date of sampling; the third sample shall be retained with seal unbroken until such time as the shipment has been accepted or a referee test called for.

(*c*) Samples shall be of an equal weight of not less than 5 lb. each when the shipment contains 30 tons or more. For smaller shipments, the weights of the samples may be reduced proportionately, provided that no sample shall weigh less than 2 lb. except by special agreement of the contracting parties.

(*d*) If the samples are taken at any place other than the place of manufacture of the material being sampled, such samples shall be taken within 24 hours of the receipt of the shipment.

(*e*) Sampling shall be conducted as expeditiously as possible in order to avoid undue exposure of the material to the air.

(*f*) Samples shall not be taken from broken packages.

B. Lump or Granular Material.

Lump or Granular Material in Bulk.

2. *In Bulk.*—Material shall be selected so that it will represent an average of all parts of the shipment, and shall not contain a disproportionate share of the top or bottom layers. This material shall comprise at least ten shovelfuls taken from different parts of the shipment. The total material so taken shall weigh not less than 100 lb. for a 30-ton shipment, with a proportionate quantity of material for shipments of other sizes, provided that at no time shall the total amount of material so taken weigh less than 50 lb. It shall be broken,

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. P. Brown, Secretary of Committee C-7 on Lime, National Lime Association, 918 G St., N.W., Washington, D. C.

if necessary, to pass a 1-in. ring, thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared.

Lump or Granular Material in Packages.

3. *In Packages.*—At least 2 per cent of the packages shall be sampled, the packages to be taken from various parts of the shipment, and at no time shall less than 5 packages be sampled. The contents of each of the packages so taken shall be put in a pile, broken, if necessary, to pass a 1-in. ring, thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared.

C. Powdered Material.

Powdered Material, in Bulk.

4. *In Bulk.*—A sampling tube shall be used which takes a core of not less than 1 in. in diameter, and which is of sufficient length to permit the taking of a core from the top to the bottom of the mass being sampled. Cores shall be taken from at least 10 separate parts of the shipment. The cores so taken shall be thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared. A minimum quantity of 100 lb. shall be drawn for a shipment of 30 tons of material, with a proportionate quantity of material for shipments of other sizes provided that at no time shall less than 50 lb. be drawn as the original portion.

Powdered Material, in Packages.

5. *In Packages.*—A sampling tube shall be used which takes a core of not less than $\frac{1}{2}$ in. in diameter. The tube shall be so inserted into the package that it shall pass substantially the entire length of the package; so as to take a core of the material being sampled from substantially the entire length of the package. Material thus taken from individual packages shall be thoroughly mixed and quartered, and the triplicate samples for testing shall be taken from the material so drawn and prepared.

Individual packages shall be taken from various parts of the shipment. At least $1\frac{1}{2}$ per cent of the packages shall be sampled, and at no time shall less than 5 packages be sampled.

D. Treatment of Sample at Laboratory.

Sample for Chemical Analysis.

6. The sample as received at the laboratory shall be thoroughly mixed, and reduced in quantity by the usual methods of quartering, to give a minimum portion of 75 g. This portion shall be ground, either by suitable mechanical device, or by hand in an agate mortar, until it all passes a No. 100 sieve. It shall then be thoroughly mixed and placed in an air-tight container for use in the determination of the chemical composition.

Samples for Special Tests. 7. Samples to be used for such special tests as may be required by individual specifications shall be obtained by mixing and quartering the material remaining after removal of the 75-g. portion for chemical analysis. The quantity of sample and the screen size of the particles will depend upon the requirements of the individual specifications.

II. INSPECTION.

Inspection. 8. When inspection and sampling are to be conducted at the point of manufacture, the manufacturer shall afford the inspector representing the purchaser all reasonable facilities for inspection and sampling which shall be so conducted as not to interfere unnecessarily with the operation of the works.

III. REJECTION.

Rejection. 9. (*a*) Rejection of material based on failure to pass the tests prescribed in the specifications shall be reported within ten days from the taking of the samples, and the cause for rejection shall be stated.

(*b*) The samples which represent rejected material shall be kept in air-tight, moisture-proof containers for at least five days from the date of the original test report.

IV. RETESTING.

Retesting. 10. (*a*) Either of the contracting parties may make claim for a retest within five days of the date of the original test report. The expense of the retest shall be borne by the party demanding such retest.

(*b*) Should the contracting parties be unable to reach a mutually satisfactory agreement based upon the results of the original test, the third sample of material shall be delivered to a referee laboratory for test and the results of this referee test shall be binding on both parties.

V. PACKING.

Packing. 11. *Lump Lime.*—Lump lime may be shipped in bulk in carload lots, in wooden barrels or steel containers holding 180 lb. or 280 lb. net each, or in pasteboard cartons holding 90 lb. net each.

12. *Pulverized Lime.*—Pulverized lime may be shipped in bulk in carload lots, or in cloth or paper bags.

13. *Hydrated Lime.*—Hydrated Lime shall be shipped in cloth bags holding 100 lb. net each, or in paper bags holding 50 lb. net each.

VI. MARKING.

Marking. 14. Each shipment of material shall carry with it some means of identification, stating the particular contract on which the purchase and shipment were made.

15. Each package shall have legibly marked thereon, the net weight of its contents, the name of the manufacturer, the place of manufacture, and the brand name if any. This marking shall comply with all requirements of the Federal Lime Barrel Act, entitled "An Act to Standardize Lime Barrels (Public No. 228—Congress—S5425)," and with such other Federal or State laws as may be applicable to the shipment in question.

16. In addition to the above information, the following guarantee may be marked on each package or shipment: "Guaranteed by (name of manufacturer) to meet the specifications of the American Society for Testing Materials for (name of material)."

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO HOLLOW TILE.[1]

Serial Designation: C 43 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1921; REVISED, 1923.

I. TILE.

1. *Hollow Tile.*—Hollow building units with parallel cells.

NOTE.—In the present state of the art the term "hollow tile," if used without a qualifying adjective, is generally understood to mean clay hollow tile.

The term "terra cotta," which is applied to ornamental building units of burned clay, should not be used to designate hollow tile.

2. *Load-Bearing Tile.*—Hollow tile for use as a load-bearing structural member in floors, walls, etc.

(*a*) *Hollow Floor Tile.*—Hollow tile for use as a structural unit in floor arches or spans.

(*b*) *Foundation Tile.*—Hollow tile for use below the first floor or grade line for carrying the superstructure.

(*c*) *Side-Construction Tile.*—Hollow tile designed to receive its principal stress at right angles to the direction of its cells.

(*d*) *End-Construction Tile.*—Hollow tile designed to receive its principal stress parallel to the direction of its cells.

(*e*) *Back-up Tile.*—Hollow tile of suitable dimensions for use as backing in walls faced with brick, stone, or other facing material.

(*f*) *Book Tile.*—Hollow tile resembling a book in shape, having tongue and groove edges, and designed to fill space between supporting members of a roof or similar structures.

(*g*) *Vitrified Hollow Tile.*—Clay hollow tile burned to a temperature to produce vitrification but not necessarily glazed.

(*h*) *Salt-Glazed Tile.*—Clay hollow tile with a vitreous glaze on its surfaces produced by burning salt in the kiln at the temperature used in finishing the burning.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. F. J. Huse, Secretary of Committee C-10 on Hollow Building Tile, The Hollow Building Tile Association, 1409 Conway Building, Chicago, Ill.

3. *Hollow Tile Fireproofing.*—Hollow tile for use for the protection of structural members against fire; also used in non-bearing partitions and for furring.

(*a*) *Split Tile.*—Hollow tile which has been knifed parallel with its cells in the process of manufacturing for the purpose of separation into two units.

(*b*) *Partition Tile.*—Hollow tile for use in building interior partitions, subdividing areas or for enclosing stairways or other shafts, and carrying no superimposed load.

(*c*) *Furring Tile.*—Tile of suitable design for lining the inside of masonry walls and carrying no superimposed load.

(*d*) *Porous Hollow Tile.*—Clay hollow tile in which the natural porosity of the clay has been increased by the admixture of other ingredients.

II. RAW MATERIALS.

4. *Shale.*[1]
5. *Fire Clay.*[1]
6. *Surface Clay.*[1]

III. DESIGNATION OF DIMENSIONS.

7. *Length.*—In the case of hollow tile, that dimension measured between its cut ends.

8. *Thickness.*—In the case of hollow tile, that dimension designed to lie at right angles to the face of the wall, floor, or other member in which it is used.

9. *Width.*—In the case of hollow tile, that dimension measured at right angles to the direction of its thickness and length.

NOTE.—In practice, the first dimension given represents thickness; the second width; the third, length.

IV. PARTS, OPENINGS AND SURFACE FEATURES.

10. *Shell.*—In the case of hollow tile, the outer walls.

11. *Webs.*—In the case of hollow tile, the partitions dividing it into cells.

12. *Cells.*—In the case of hollow tile, the openings running parallel with its shell and webs.

13. *Scoring.*—In the case of hollow tile, the grooves formed in the exterior faces of the shell to increase the bond of mortar, plaster, or stucco.

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[1] Definitions of the terms shale, fire clay and surface clay and of clays in general as applied to refractories, are now under consideration by Committee E-8 on Nomenclature and Definitions, in cooperation with the several standing committees interested.—ED.

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO THE GYPSUM INDUSTRY.[1]

Serial Designation: C 11 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1916; Revised, 1921, 1922, 1923.

Accelerator.—The term accelerator shall apply to any material or substance which, when used in stucco, plaster, mortar, concrete, etc., will hasten set beyond the limit of testing error.

Aggregate.—The term aggregate shall refer to the inert material used as filler in stucco, plaster, mortar, concrete mixtures, etc., without regard to its function as a binding material.

Binder.—The term binder shall refer to any fibrous material which will increase the cohesiveness of plaster and stucco while in its plastic state.

Cement.—The term cement applies to any material, or a mixture of such materials (without aggregate) which, when in a plastic state, possesses adhesive and cohesive properties, and hardens in place. The word "cement" is used without regard to the composition of the material, and does not define its use or location as do the words "stucco," "plaster" and "mortar."

Consistency.—The term consistency is used to denote the degree of wetness of a plastic mixture.

Lath.—The term lath is used to designate a material whose primary function is that of a base or background for the reception of plaster or stucco. The word "lath" is used without regard to the composition of the material, defining only its use.

Mortar.—The term mortar applies to any material used in a plastic state that can be trowelled, and becomes hard in place, uniting such materials as brick, stone, tile, gypsum tile or blocks, terra cotta, etc., in building walls, partitions, columns, foundations, piers, floors, roof arches, etc. The word "mortar" is used without regard to the composition of the material, defining its use as a bonding material as contrasted with the words "stucco" and "plaster."

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

Plaster.—The term plaster applies to any material used in a plastic state to form a hard covering for the interior surfaces, walls and ceilings, etc., of any building or structure. The word "plaster" is used without regard to the composition of the material, defining only its use and location of use as contrasted with the words "stucco" and "mortar."

Plasticity.—The term plasticity is used to denote the yielding property of a wet mixture to change of form.

Retarder.—The term retarder applies to any material or substance which, when used in stucco, plaster, mortar, concrete, etc., will retard set beyond the limit of testing error.

Stucco.—The term stucco refers to any material used in a plastic state to form a hard covering for the exterior walls or other exterior surfaces of any building or structure. The word "stucco" is used without regard to the composition of the material, defining only its use and location of use, as contrasted with the words "plaster" and "mortar."

Wood Fiber.—The term wood fiber applies to a material produced by grinding or shredding wood.

TENTATIVE SPECIFICATIONS
FOR
RAW TUNG OIL[1]

Serial Designation: D 12 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

I. PROPERTIES AND TESTS.

Properties.

1. Raw tung oil shall conform to the following requirements:

	MAXIMUM.	MINIMUM.
Specific gravity at 15.5°/15.5° C	0.943	0.9400
Acid number (Alcohol-Benzol)	8.0	.....
Saponification number	195	190
Unsaponifiable matter, per cent	0.75	.....
Refractive index at 25° C	1.520	1.5165
Iodine number (Wijs)	.....	163
Heating test, minutes	12	.....

II. METHODS OF TESTING.

SOLUTIONS REQUIRED.

2. The following reagents will be required:

Solutions Required.

Standard Sodium Thiosulfate Solution.—Dissolve pure sodium thiosulfate in distilled water that has been well boiled to free it from carbon dioxide in the proportion so that 24.83 g. crystallized sodium thiosulfate will be present in 1000 cc. of the solution. It is best to let this solution stand for about two weeks before standardizing. Standardize with pure resublimed iodine. (See Treadwell-Hall, *Analytical Chemistry*, Vol. II, third edition, p. 646.) This solution will be approximately N/10 and it is best to leave it as it is after determining its exact iodine value, rather than to attempt to adjust it to exactly N/10 strength. Preserve in a stock bottle with a guard tube filled with soda lime.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Purity of Raw Tung Oil (Serial Designation: D 12 - 16), 1921 Book of A.S.T.M. Standards.

Starch Solution.—Stir up 2 to 3 g. of potato starch or 5 g. soluble starch with 100 cc. of 1-per-cent salicylic acid solution, add 300 to 400 cc. boiling water, and boil the mixture until the starch is practically dissolved. Dilute to 1 liter.

Potassium Iodide Solution.—Dissolve 150 g. of potassium iodide free from iodate in distilled water and dilute to 1000 cc.

Iodine-Monochloride Solution.—Dissolve iodine in glacial acetic acid that has a melting point of 14.7 to 15° C. and is free from reducing impurities in the proportion so that 13 g. of iodine will be present in 1000 cc. of the solution. The preparation of the iodine-monochloride solution presents no great difficulty, but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine, over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. Set aside a small portion of this solution, while pure, and pass dry chlorine into the remainder until the halogen content of the whole solution is doubled. Ordinarily it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine, which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided.

Chloroform.—Should be U. S. P.

Standard Sodium Hydroxide Solution.—Prepare a stock concentrated solution of sodium hydroxide by dissolving NaOH in water in the proportion of 200 g. NaOH to 200 cc. water. Allow this solution to cool and settle in a stoppered bottle for several days. Decant the clear liquid from the precipitate of sodium carbonate into another clean bottle. Add clear barium hydroxide solution until no further precipitate forms. Again allow to settle until clear. Draw off about 175 cc. and dilute to 10 liters with freshly boiled distilled water. Preserve in a stock bottle provided with a large guard tube filled with soda lime. Determine the exact strength by titrating against pure benzoic acid (C_6H_5COOH) using phenolphthalein as indicator. (See Bureau of Standards *Scientific Paper No. 183.*) This solution will be approximately N/4, but do not attempt to adjust it to any exact value. Determine its exact strength and make proper corrections in using it.

Alcoholic Sodium Hydroxide Solution.—Dissolve pure NaOH in 95-per-cent ethyl alcohol in the proportion of about 22 g. per 1000 cc. Let stand in a stoppered bottle. Decant the clear liquid into another bottle, and keep well stoppered. This solution should be colorless or only slightly yellow when used; it will keep colorless longer if the alcohol is previously treated with NaOH (about 80 g. to 1000 cc.), kept at about 50° C. for 15 days, and then distilled. For an alternate method see *Journal*, American Chemical Society, 1906, p. 395.

Half Normal Sulfuric Acid Solution.—Add about 15 cc. H_2SO_4 (sp. gr. 1.84) to distilled water, cool and dilute to 1000 cc. Determine the exact strength by titrating against freshly standardized NaOH or by any other accurate method. Either adjust to exactly N/2 strength or leave as originally made, applying appropriate correction.

METHODS.

Methods of Testing.

3. The oil shall be tested in accordance with the following methods:

General.—The laboratory sample shall be thoroughly mixed by shaking, stirring, or pouring from one vessel to another and the samples for the individual tests taken from this thoroughly mixed sample.

Specific Gravity.—Use a pyknometer accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making the test at 15.5° C., water being 1 at 15.5° C.

Acid Number.—Weigh from 5 to 10 g. of the oil. Transfer to a 300-cc. Erlenmeyer flask. Add 50 cc. of a mixture of equal parts by volume of 95-per-cent ethyl alcohol and c. p. reagent benzol. (*This mixture should be previously titrated to a very faint pink with dilute alkali solution, using phenolphthalein as an indicator*). Add phenolphthalein indicator and titrate at once to a faint permanent pink color with the standard sodium hydroxide solution. Calculate the acid number (milligrams KOH per gram of oil).

Saponification Number.—Weigh about 2 g. of the oil in a 300-cc. Erlenmeyer flask. Add 25 cc. alcoholic sodium hydroxide solution. Put a condenser loop inside the neck of the flask and heat on the steam bath for one hour. Cool, add phenolphthalein as indicator, and titrate with N/2 H_2SO_4. Run two blanks with the alcoholic sodium hydroxide solution. These should check within 0.1 cc. N/2 H_2SO_4. From the difference between the number of cubic centimeters of N/2 H_2SO_4 required for the blank and for the determination, calculate the saponification number (milligrams KOH required for 1 g. of the oil).

Unsaponifiable Matter.—Weigh 8 to 10 g. of the oil. Transfer to a 250-cc. long-neck flask. Add 5 cc. of strong solution of sodium hydroxide (equal weights of NaOH and H_2O), and 50 cc. 95-per-cent ethyl alcohol. Put a condenser loop inside the neck of the flask and boil for two hours. Occasionally agitate the flask to break up the liquid but do not project the liquid onto the sides of the flask. At the end of two hours remove the condenser and allow the liquid to boil down to about 25 cc.

Transfer to a 500-cc. glass-stoppered separatory funnel, rinsing with water. Dilute with water to 250 cc., add 100 cc. redistilled ether. Stopper and shake for one minute. Let stand until the two layers separate sharp and clear. Draw all but one or two drops of the aqueous layer into a second 500-cc. separatory funnel and repeat the process, using 60 cc. of ether. After thorough separation draw off the aqueous solution into a 400-cc. beaker, then the ether solution into the first separatory funnel, rinsing down with a little water. Return the aqueous solution to the seond separatory funnel and shake out again with 60 cc. of ether in a similar manner, finally drawing the aqueous solution into the beaker and rinsing the ether into the first separatory funnel.

Shake the combined ether solution with the accumulated water rinsings and let the layers separate sharp and clear. Draw off the water and add it to the main aqueous solution. Shake the ether solution with two portions of water (about 25 cc. each). Add these to the main water solution.

Swirl the separatory funnel so as to bring the last drops of water down to the stopcock, and draw off until the ether solution just fills the bore of the stopcock. Wipe out the stem of the separatory funnel with a bit of cotton on a wire. Draw the ether solution (portionwise if necessary) into a 250-cc. flask and distill off. While still hot, drain the flask into a small weighed beaker, rinsing with a little ether. Evaporate this ether, cool and weigh.

NOTE.—The unsaponifiable oil from adulterated drying oils is volatile and will evaporate on long heating. Therefore heat the beaker on a warm plate, occasionally blowing out with a current of dry air. Discontinue heating as soon as the odor of ether is gone.

Refractive Index.—Use a properly standardized Abbé refractometer at 25° C., or any other equally accurate instrument.

Iodine Number.—Place a small quantity of the sample in a small weighing burette or beaker. Weigh accurately. Transfer by dropping from 0.16 to 0.19 g. to a 500-cc. bottle having a well-ground glass stopper, or an Erlenmeyer flask having a specially flanged neck for the iodine tests. Reweigh the burette or beaker and determine the amount of sample used. Add 10 cc. of chloroform. Whirl the bottle to dissolve the sample. Add 10 cc. of chloroform to each of two empty bottles like that used for the sample. Add to each bottle 25 cc. of the

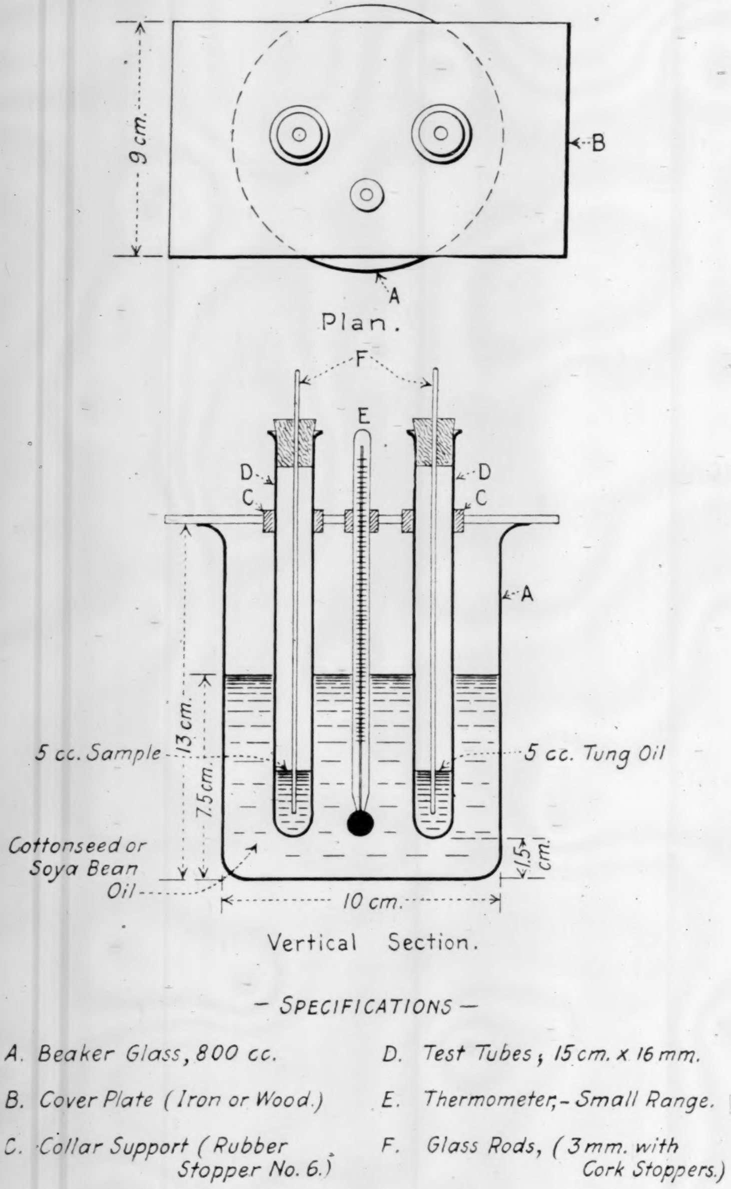
9 cm.
B
A
Plan.
F
E
D
D
C
C
A
13 cm.
7.5 cm.
5 cc. Sample
5 cc. Tung Oil
Cottonseed or Soya Bean Oil
1.5 cm.
10 cm.
Vertical Section.
– SPECIFICATIONS –
A. Beaker Glass, 800 cc.
B. Cover Plate (Iron or Wood.)
C. Collar Support (Rubber Stopper No. 6.)
D. Test Tubes; 15 cm. x 16 mm.
E. Thermometer, - Small Range.
F. Glass Rods, (3 mm. with Cork Stoppers.)

FIG. 1.—Tung Oil Heat Test Apparatus (Revised 1920).

NOTE: Collars *C* may be omitted and tubes supported in present place by aid of wire gauze placed in bottom of oil bath and resting on bottom of beaker.

Wijs solution and let stand with occasional shaking for 30 minutes in a dark place at a temperature of from 21 to 23° C. Add 10 cc. of the 15-per-cent potassium iodide solution and 100 cc. of water, and titrate with standard sodium thiosulfate using starch as the indicator. The titrations on the two blank tests should agree within 0.1 cc. From the difference between the average of the blank titration and the titration on the samples and the iodine value of the thiosulfate solution, calculate the iodine number of the samples tested. (Iodine number is given in centigrams of iodine to 1 g. of sample.)[1]

Heating Test.—Test tubes containing the oil should be 15 cm. by 16 mm., with a mark near the bottom to indicate 5 cc., and closed by a cork so perforated that a glass rod 3 mm. in diameter can move freely,

Fill an 800-cc. glass beaker (height, 13 cm.; diameter, 10 cm.). with cottonseed oil or soya bean oil to a height of 7.5 cm. Place a thermometer so as to be 1.5 cm. from the bottom of the bath. (See Fig. 1.)

Use a nitrogen-filled, chemical thermometer; engraved stem; total length 4 to 4½ in., graduated from 210 to 310° C. in 2° intervals; the length between 210 and 310° C. not less than 2½ in. Thermometer glass shall be well annealed.

When the bath temperature is 293° C. (560° F.) and very slowly rising at this point, place the tube containing 5 cc. of the oil to be tested and the tube containing 5 cc. of a control sample of known value, so that the bottom of each tube is level with the lowest part of the bulb of the thermometer. If desired, the collars *C* may be omitted and the tubes allowed to rest upon a piece of wire gauze placed in the bottom of the oil bath so that the tubes will be 1.5 cm. from the bottom of the bath. Note the time. Remove the source of heat for about 45 seconds and then reapply. Before 2 minutes have elapsed the temperature of the bath will have fallen to 282° C. (530° F.), at which point it should be kept as steady as possible. When the samples have been in the bath 9 minutes, raise the glass rods at intervals of ¼ minute. Note the time when each sample becomes firmly set. At this period the oil will be so stiff that the entire tube may be lifted by aid of the rod if the collar *C* is omitted from the apparatus. As setting or jellying takes place within a few seconds of fluidity, a good end determination is afforded. Remove the specimens. Heat the bath again to 293° C., and repeat the experiment with fresh portions of the sample.

No stirrer is used in the bath. A screen around the bath enables the temperature to be more easily reached. When the bath oil has become tarry and viscid, it should be renewed; otherwise heating may be irregular.

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[1] It is always well to include a test on a sample of tung oil of known iodine value. This may be kept in a dark-colored bottle as a standard.

Quality Test.[1]—Into an ordinary agateware casserole, having a bottom diameter of 3 in., weigh 150 g. of the tung oil to be tested, and set the casserole on a wide-flanged tripod having a 3-in. opening. The object of the flange is to prevent super-heating of the sides of the casserole. Heat rapidly with a full Bunsen flame, stirring with a thermometer, until the heat reaches 540° F. (282.2° C.). Turn down the flame and hold the heat as near 540° F. (282.2° C.) as possible, stirring with the thermometer, until on lifting the latter the oil drops with a pronounced string, showing that polymerization has started. The time required after reaching 540° F. (282.2° C.) until the string is noted, is the time of the heat test. For pure tung oils this will not exceed eight minutes. As soon as the oil strings, remove the lamp and the thermometer, and stir with a stiff spatula until the oil is solid. After stringing, a pure tung oil will require not over 40 seconds more to become solid. When solid, allow to stand just one minute, then turn out, upside down, on clean paper and cut with a clean spatula. Pure tung oil gives a gel that is dry, not adhering to the spatula when cut, that is firm, crumbling under pressure of the spatula without sticking, and the cut portions should crumble under pressure like dry bread crumbs. Adulterated tung oil gives a gel that is soft, sticky, and which will not crumble.

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[1] Furnished by R. S. Worstall.

TENTATIVE METHOD OF TEST
FOR
SPECIFIC GRAVITY OF PIGMENTS[1]

Serial Designation: D 153 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

I. APPARATUS

Apparatus.

1. The apparatus shall consist of the following:

(*a*) A pyknometer as shown in Figs. 1 (*a*) or 1 (*b*), having a capacity of 50 cc.

(*b*) A water bath consisting of a vessel filled with sufficient water to permit of only a very gradual rise in temperature and equipped with a stirring device, preferably air blown.

(*c*) An open tube manometer, made of glass tubing 6 mm. in diameter, filled with mercury to approximately 86 cm., fitted with pressure tubing attached to a Y tube leading to the desiccator and the pump.

NOTE.—The difference in levels of the mercury in the manometer when the system is in operation, subtracted from the barometer reading taken at the same time, gives the vacuum of the system in millimeters of mercury. The difference between the barometer and the manometer reading should not exceed 3 mm.

(*d*) A glass desiccator, having a hole at the side, constructed with heavy walls to withstand a vacuum of one atmosphere.

(*e*) A laboratory water vacuum pump to expel the greater portion of air in the desiccator.

(*f*) An oil vacuum pump with motor to give a vacuum of not more than 3 mm.

NOTE.—The Nelson oil pump is satisfactory. This pump has a displacement of approximately 200 cu. in. per minute or 7 cu. ft. per hour at a speed of 900 r.p.m. It will evacuate a flask of one-liter capacity to a vacuum of 1 mm. in two minutes.

(*g*) A weighing bottle with cork. The neck shall be small enough to fit inside the neck of the pyknometer. This latter requirement is essential, since small quantities of pigment easily adhere to the ground-glass joint of the pyknometer.

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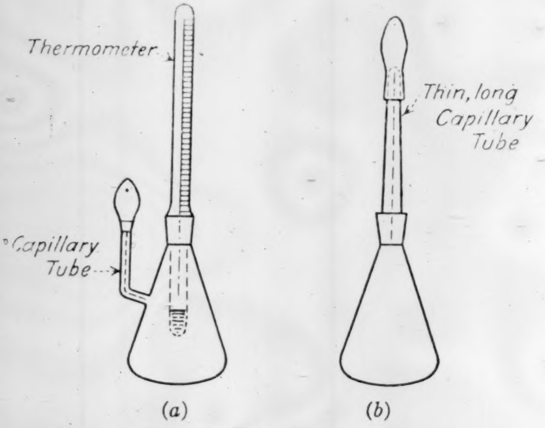
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

(*j*) A thermometer having a range of from 0 to 60° C. graduated in 0.1° C.

II. PROCEDURE

Standardization of Pyknometers.

2. The pyknometer shall be filled with freshly-boiled distilled water and brought to a temperature of 15.6° C. It shall be dried and weighed as specified in Section 7. It shall then be cleaned, weighed, and dried. It shall then be filled with the kerosene to be used in making the test and again brought to a temperature of 15.6° C., and dried and weighed in the same manner as before. The specific gravity of the kerosene shall be calculated from the formula:



(*a*) (*b*)

FIG. 1.

$$\text{Specific Gravity } 15.5°/15.5° \text{ C.} = \frac{\text{Weight of Kerosene}}{\text{Weight of Water}}$$

Drying.

3. The pigment shall be dried in an oven at 105° C. for 2 hours.

NOTE.—It is preferable to use an electric oven for this purpose.

Weighing.

4. A sample of the pigment shall be weighed, by difference, in the weighing bottle. For blacks, blues, and lakes of light specific gravity, about 1 g. should be used; for inert crystallin pigments, about 4 g.; for opaque white pigments, 7 to 10 g.; and for red lead, from 15 to 20 g. should be used.

NOTE.—Due to the hygroscopic nature of some of the pigments it is necessary to use a weighing bottle fitted with a cork stopper.

Transferring to Pyknometer.

5. Sufficient kerosene shall be poured into the pyknometer to form a $\frac{1}{4}$-in. layer in the bottom and a quantity of pigment from the weighing bottle shall be added reaching approximately three-fourths of the distance to the kerosene level. The kerosene shall always cover the pigment. The sample shall be stirred with a polished round-bottom glass rod until completely covered by the kerosene, more kerosene being added from the wash bottle if necessary. The rod shall be washed with kerosene.

Removal of Occluded Air.

6. The pyknometers shall be placed in the desiccator, which shall then be closed and attached to the water pump until the greater part of the air is expelled from the system. This takes from 5 to 10 minutes. The system shall then be closed with a pinchcock and the desiccator attached to the oil pump for the removal of the small amounts of air given off at the low pressures obtainable with the oil pump. The manometer is used to indicate whether the oil pump is giving the proper vacuum. When the manometer indicates that the vacuum, which should not be greater than 3 mm., is constant, the oil pump may be cut off for short periods, precaution being taken that the vacuum does not change materially due to leakage. It will be noticed that bubbles of air come from the pigments very rapidly at first and that this action gradually decreases and finally stops altogether. The time required for complete removal of air varies from 30 minutes to two hours, depending upon the nature of the pigment. When no more bubbles can be seen, it is assumed that all the occluded air has been given off and that the pigment is thoroughly wet with kerosene. Air can then be slowly admitted to the desiccator by means of the pinchcock.

Filling and Bringing to Temperature.

7. The pyknometer shall be taken from the desiccator and filled with kerosene, care being taken to add a sufficient quantity to prevent the formation of air bubbles when placement of the thermometer is made. The thermometer shall be placed in the water bath, which shall be cooled with ice to a temperature of between 10 and 13° C. The pyknometer shall be placed in the bath and be permitted to come to constant temperature. The pyknometer thermometer or capillary tube shall then be inserted. Enough warm water shall be added to the bath to raise the temperature suddenly to about 14.5° C. in order to expand the kerosene and prevent it from creeping down the capillary and admitting a small amount of air. The bath shall be allowed to come to a temperature of 15.6° C. The capillary tube shall be wiped with filter paper and the cap put on. All temperatures on the thermometer in the bath shall be read, but not on the thermometer in the pyknometer. The pyknometer shall be removed from the bath and

dried. It shall then be allowed to stand for 30 minutes to enable it to come to room temperature, and weighed.

NOTE.—It is advisable to allow the pyknometer to stand approximately the same time before each weighing so as to compensate for slight errors due to evaporation at the joints.

Specific Gravity.

8. The specific gravity shall be calculated from the formula:

$$\text{Specific Gravity of Pigment} = \frac{P \times S}{(P + K) - F}$$

in which K = Weight of the bottle filled with kerosene only;
P = Weight of pigment used;
F = Final weight of the bottle with pigment and kerosene;
S = Specific gravity of the kerosene used.

Precautions.

9. Before a new desiccator is used for the first time, it shall be wrapped in a towel and tested under the vacuum to be used, great care being exercised in handling the desiccator when the vacuum is on, as any sudden jar may cause it to collapse.

Number of Samples.

10. It has been found convenient to run six samples at one time, the desiccator specified being of the proper size to accommodate this number.

TENTATIVE METHODS OF TESTING OLEO-RESINOUS VARNISHES[1]

Serial Designation: D 154 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

1. (*a*) All tests shall be made at room temperature between 21 and 32° C. (70 and 90° F.).

(*b*) All tests shall be made in diffused light (not in direct sunlight).

(*c*) When a can of varnish has been opened and part of its contents has been used, the remainder shall immediately be placed in air-tight containers which the varnish entirely fills, leaving not more than 2 per cent of air space.

(*d*) The tin panels used shall be cut from bright tin plate weighing not more than 25 g. nor less than 19 g. per square decimeter (0.51 to 0.39 lb. per sq. ft.).

NOTE.—Commercial No. 31 gage bright tin plate should weigh about 0.44 lb. per sq. ft.

It is important that the tin plate shall be within the limits prescribed. The panel shall be about 7.5 by 13 cm. (3 by 5 in.) and shall be thoroughly cleaned with benzol immediately before using.

NOTE.—It is important that the rags used in wiping the panels are clean.

I. APPEARANCE

Appearance. 2. Some of the thoroughly mixed sample shall be poured into a clear glass bottle or test tube, 1.5 to 2.0 cm. ($\frac{5}{8}$ to $\frac{13}{16}$ in.) in diameter to a depth of at least 2.5 cm. The varnish shall then be examined by transmitted light and shall be clear and transparent.

II. COLOR

Color. 3. (*a*) Standard color solutions shall be prepared by dissolving 1, 2, 3, 4, 5 and 6 g., respectively, of pure powdered potassium bichromate in 100 cc. of pure concentrated H_2SO_4 (sp. gr. 1.84). Gentle heat may be applied, if necessary, to effect the solution of bichromate.

(*b*) The standard color solutions and a sample of the varnish to be tested shall be poured into thin-walled glass tubes 1.5 to 2.0 cm. ($\frac{5}{8}$ to $\frac{13}{16}$ in.) in diameter to a depth of at least 2.5 cm. The color comparison shall be made by placing the tubes close together and looking through them by transmitted light.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

Since the potassium bichromate - sulfuric acid solution must be freshly made for this color comparison, it is frequently more convenient to compare samples with a series of permanently sealed tubes of varnish which have been previously found to be lighter in color than the standard solutions. When a sample is found to be darker than a standard tube of varnish, the bichromate standard should be made up for final decision. The color of the varnish shall be stated in terms of the standard (calling the standards No. 1, No. 2, No. 3, etc.) with which it is equal or lighter than.

III. NON-VOLATILE MATTER

Non-Volatile Matter.

4. A portion of the sample of the varnish shall be poured into a stoppered bottle or weighing pipette and weighed. About 1.5 g. of the sample shall be transferred to a flat-bottomed metal dish about 8 cm. in diameter. (Note.—A friction-top can plug is satisfactory.) The container shall be weighed again, and the exact weight of the portion of the sample transferred to the weighed dish shall be calculated by difference. The dish with its contents shall be heated for 3 hours in an oven maintained at 105 to 110° C. (221 to 230° F.). It shall then be weighed after cooling.

5. The ratio of the weight of the residue to that of the sample, expressed as a percentage, shall be taken as the percentage of non-volatile matter in the varnish.

IV. TEST FOR ELASTICITY OR TOUGHNESS

6. The elasticity or toughness of the varnish shall be determined by proportionately reducing its elasticity or toughness by the addition of a standard solution of Run Kauri gum in pure spirits of turpentine.

Preparation of Standard Run Kauri.

7. (*a*) A distillation flask, water-cooled condenser and a tared receiver shall be arranged on a balance. Clear, bright, hard pieces of Kauri gum broken to the size of a pea shall be placed in the flask to about one-third its capacity. The gum shall be carefully melted and distilled until 25 per cent by weight is collected in the tared receiver. At the end of the distillation the thermometer in the distillation flask with the bulb at the level of the discharging end of the flask should register about 316° C. (600° F.). The residue shall be poured into a clean pan and when cold it shall be broken into small pieces.

(*b*) *Standard Run Kauri Solution.*—A quantity of the small broken pieces of Run Kauri, together with twice its weight of freshly re-distilled spirits of turpentine, using only that portion distilling between 153 and 170° C. (308 and 338° F.), shall be placed in a carefully tared beaker and dissolved by heating to a temperature of about 149° C. (300° F.). It shall then be brought to correct weight when cooled by the addition of the amount of re-distilled spirits of turpentine necessary to replace the loss by evaporation during the dissolving of the gum.

Procedure.

8. (*a*) Having carefully determined the non-volatile content of the varnish in accordance with Section 4, 100 parts of the varnish by weight shall be taken and to it shall be added an amount of the standard Run Kauri solution equivalent to 50 per cent by weight of the non-volatile matter in the varnish and mixed thoroughly.

(*b*) The varnish shall be flowed upon one of the tin panels described in Section 1 (*d*) and the panel be permitted to stand in a nearly vertical position at room temperature for nearly one hour. The panel shall then be placed in a horizontal position in a properly ventilated oven and baked for five hours at from 95 to 100° C. The panels shall then be removed from the oven and permitted to cool at room temperature (preferably 24° C. (75° F.)) for 15 minutes.

Bending the Panel.

9. The panel shall be placed with the varnished side uppermost over a 3 mm. ($\frac{1}{8}$-in.) rod, held firmly by suitable supports, at a point equi-distant from the top and bottom edges of the panel and bent double rapidly. The varnish shall show no cracking whatsoever at the point of bending. For accurate results the bending of the panel should always be done at 24° C. (75° F.) for a lowering of the temperature will lower the percentage of reduction that the varnish will withstand without cracking, while an increase in temperature increases the percentage of reduction that the varnish will withstand.

10. Varnishes which do not show cracks under this test shall be reported as passing a fifty-per-cent reduction, while those that do crack shall be reported as not passing a fifty-per-cent reduction.

The varnishes which have not cracked shall be tested again, changing the amount of reduction to sixty per cent, and, if they pass this amount of reduction, they shall be reduced to seventy per cent.

In a similar manner, varnishes which have cracked at fifty per cent shall be tested, using reductions of thirty and forty per cent.

In this way the limits shall be determined within ten per cent at which a varnish passes one amount of reduction and does not pass the next. For example, varnishes may be reported as passing forty per cent, and breaking at fifty per cent.

NOTE.—It is suggested that a 20-g. sample of varnish shall be sufficient for each reduction. If the non-volatile content of the varnish should be 48.6 per cent, then 4.86 g. of standard Run Kauri solution should be added to the 20 g. of varnish and a fifty-per-cent reduction will be obtained.

TENTATIVE METHODS OF TESTING SHELLAC[1]

Serial Designation: D 29 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

DETERMINATION OF MATTER INSOLUBLE IN HOT ALCOHOL

(*a*) *Continuous Extraction Method* (suitable for all grades of lac).

APPARATUS

1. The extraction apparatus (Fig. 1) shall consist of a wide-neck flask in which is suspended a metal return condenser. From the lower part of this condenser is hung a siphon tube of Knoefler type. The extraction cartridge used for the determination shall be cut down to such a size that the top of the cartridge is just above the upper curve of the siphon. It shall be supported on three indentations in the glass so that there will be a little space beneath and around the cartridge to permit of a free flow of liquid.

NOTE.—Any type of siphon extractor where the siphon is continuously surrounded by the vapors of boiling alcohol may be substituted for the above form of apparatus.

SOLUTIONS REQUIRED

2. *95-per-cent Alcohol.*—Specially denatured alcohol, U. S. Internal Revenue Bureau Formula No. 1 or Formula No. 30.

METHOD

3. Prepare an extraction cartridge 26 mm. in diameter by 80 mm. in height (Schleicher and Schull No. 603 or the equivalent). Place the cartridge in the extraction apparatus, Fig. 1, and extract for 30 minutes with boiling 95-per-cent alcohol.

Dry in an air bath at 105° C., transfer to a glass-stoppered weighing bottle, cool and weigh. Dry to constant weight. A number of cartridges can be prepared and kept in glass-stoppered weighing bottles until wanted. Now weigh accurately 5 g. of the lac in a 100-cc. beaker and dissolve in 75 cc. of boiling 95-per-cent alcohol by immersing the beaker in a hot water bath until all the shellac is dissolved and the wax is in solution. Transfer this solution quickly into the weighed extraction cartridge, previously wet with hot alcohol, putting the cartridge into a carbon filter tube of suitable size supported in a hot water bath (Fig. 2), the outlet tube extending through the bottom of the bath allowing the escape of the filtrate. Wash all the residue from the beaker into the cartridge with hot 95-per-cent alcohol. Put the cartridge in the extraction apparatus (Fig. 1), and extract for exactly one hour.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

These methods, when adopted as standard, will supersede the present Standard Methods of Testing Shellac (Serial Designation: D 29 - 17), 1921 Book of A.S.T.M. Standards.

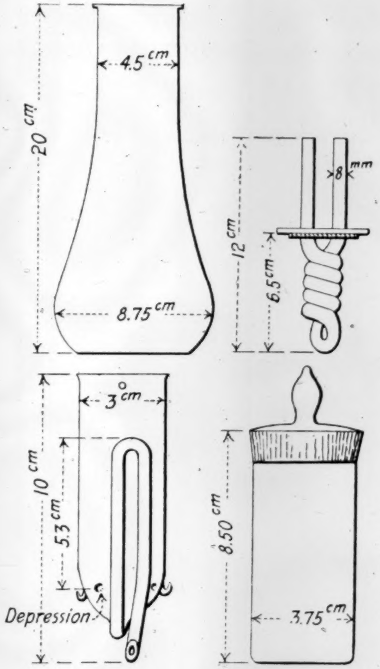

FIG. 1.—Extraction Apparatus for Alcohol-Insoluble Matter in Shellac

Keep the alcohol boiling briskly during the extraction. The rate of extraction may be controlled by the use of an electric hot-point stove, 6 in. in diameter, and using the full current of 2.2 amperes at 110 volts. The volume of alcohol in the flask should be 125 cc. Protect the flask from drafts. Under these conditions the tube should siphon over at least 33 times in 1 hour. The condenser should be able to return all the alcohol volatilized during the vigorous boiling of the contents of the flask, the object being to effect the maximum extraction during the specified time.

The weight of the residue insoluble in alcohol thus obtained, divided by the weight of the sample, and this quotient multiplied by 100 is the percentage of alcohol-insoluble matter in the lac.

NOTE.—When the determination of alcohol-insoluble matter in bleached shellac is required, the sample shall be dried if in the form of bars or hanks or ground shellac, as the water present dilutes the alcohol to a point where solution may not be complete. It is recommended that in preparing shellac for this determination, a separate portion be dried by exposure to the air in a thin layer, without the application of heat.

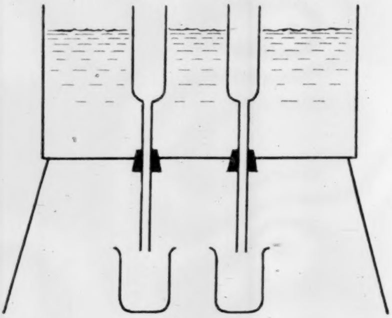

FIG. 2.—Filtering Device

(*b*) *Gooch Filtration Method* (Not Applicable for Stick, Seed or Grain Lac and Bleached Shellac).

SOLUTIONS REQUIRED

4. *95-per-cent Alcohol.*—Specially denatured alcohol, U. S. Internal Revenue Bureau Formula No. 1 or Formula No. 30.

METHOD

5. Grind a 50-g. sample fine enough to pass a 40-mesh sieve. Weigh accurately 2 g. of the sample and transfer to a small beaker, heat the shellac with 25 cc. of 95-per-cent alcohol. Prepare a Gooch crucible with an asbestos pad in the usual manner[1] and dry it to constant weight. Arrange the crucible for filtration by suction and pour sufficient boiling alcohol through it to thoroughly heat the crucible.

NOTE.—A cold crucible will congeal the wax and prevent filtration.

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[1] For the preparation of the Gooch crucible see any standard text on quantitative analysis, for example, Fresenius (Cohn Translation), p. 120, 1904, or Treadwell-Hall, third edition, Vol. II, p. 26.

Immediately filter the boiling solution through the crucible, using suction, transfer the insoluble material from the beaker to the crucible, using a "policeman" if necessary and a wash bottle containing hot alcohol until the washings are colorless and then wash five more times, nearly filling the crucible each time with boiling alcohol.

NOTE.—It will be necessary to shut off the suction momentarily to fill the crucible.

Wash off any film of shellac on the sides or bottom of the crucible with hot alcohol and dry to constant weight in an oven at 105 to 110° C. The weight of the residue in the crucible, multiplied by 100 and divided by the weight of the sample, is the percentage of material insoluble in hot alcohol.

DETERMINATION OF ROSIN

SOLUTIONS REQUIRED

6. *Acetic Acid.*—99-per-cent glacial acetic acid having a melting point of 14.8° C., free from reducing impurities as shown by its action on a bichromate in sulfuric acid.

NOTE.—If these requirements are not met the results of the rosin determination will be erratic.

Iodine Monochloride Solution.—Dissolve 13 g. of iodine in a liter of acetic acid, using gentle heat if necessary, determining the strength by titration with thiosulfate. Set aside 50 to 100 cc. of the solution and introduce dry chlorine gas into the remainder until the characteristic color change occurs, and the halogen content has been doubled. By titration, ascertain if the halogen content has been more than doubled, and if so reduce it by adding the requisite quantity of the iodine acetic acid solution. A slight excess of iodine does no harm but an excess of chlorine must be avoided.

Chloroform.—Should be chemically pure.

Sodium Thiosulfate Solution.—Dissolve 24.83 g. of the pure salt in a liter of cold, boiled, distilled water. Standardize by titrating against freshly resublimed iodine. It is recommended that the resublimed iodine be collected into a glass-stoppered weighing bottle and weighed after cooling.

Starch Solution.—Dissolve 0.2 g. of starch per 100 cc. of water and boil.

METHOD

7. Introduce 0.2 g. of ground shellac into a 250 cc. dry bottle of clear glass with a ground-glass stopper, add 20 cc. of glacial acetic acid and warm the mixture gently on top of a hot water bath until

solution is complete (except for the wax). A pure shellac is rather difficultly soluble; solution is quicker according to the proportion of rosin present. Add 10 cc. of chloroform and cool the solution to 21.5 to 22.5° C. The bottles should be allowed to stand half immersed in a shallow pan of water, well insulated or equipped with a suitable thermostat, at least 30 minutes at 21.5 or 22.5° C. before the Wijs solution is added. Add 20 cc. of Wijs solution (which shall be at a temperature of 21.5 to 22.5° C.) from a pipette, having a rather small delivery aperture (about 30 seconds). Close the bottle, place it back into the pan of water, and note the time. The bottles must be kept half immersed in water at 21.5 to 22.5° C. during the one hour that the shellac is exposed to the Wijs solution. Agitate the bottles occasionally during that hour.

NOTE.—If a number of samples are being run, at least 5 minutes should be allowed between the additions of the Wijs solution.

After exactly one hour, add 10 cc. of freshly prepared 10-per-cent potassium iodide water solution, washing into the bottle any Wijs solution on the stopper with the same. Titrate the solution immediately with the 0.1 *N* sodium thiosulfate solution, allowing the solution to run in slowly (about 25 to 30 cc.) with vigorous shaking until the solution becomes a straw color. Now add 15 cc. of freshly prepared starch solution and finish titrating. The end point is sharp, as the reaction products of shellac remain dissolved in the chloroform; any color returning after ½ minute or so is disregarded.

A blank determination shall be run at the same time on the reagents. The blank is necessary on account of the well-known effect of temperature changes on the volume, and possibly loss of strength of the Wijs solution. A sample of pure shellac of known iodine value should also be run with every set of tests on unknown samples.

In the case of grossly adulterated samples, or in the testing of pure rosin, it is necessary to use, instead of 0.2 g. of material, a smaller amount (0.15 g. or 0.1 g.) in order that the excess of iodine monochloride may not be too greatly reduced, since the excess of halogen is one of the factors in determining the amount of absorption. In case less than 25 cc. of the thiosulfate solution are required, another test should be made, using a smaller amount of the shellac to be tested.

In weighing shellac, some difficulty is at times experienced on account of its electrical properties. In very dry weather it may be found that the necessary handling to prepare it for weighing has electrified it, and that it may be necessary to leave it on the balance pan at rest for a few minutes before taking the final weight.

No pure shellacs show a higher iodine absorption than 18. As pure shellac is relatively a high-priced material and as the variation between its highest and lowest figures is not great, it is recommended that 18 should be taken as the standard figure for rosin-free shellac, determined by the method above described.

The determination for added rosin in bone-dry bleached shellac is run the same as above, except that the iodine absorption of pure bleached shellac is taken as 10 instead of 18.

It is recommended that the value for the iodine number of rosin be taken as 228. The results of using in this method the value of 18 as the iodine number of shellac and 228 as the number of rosin, may be that a slightly lower percentage of rosin, under some circumstances, will be found than that which is actually present.

The percentage of rosin shall be determined from the formula:

Iodine number of shellac	18
" " " rosin	228
" " " mixture	*x*

$$\frac{(x - 18)}{(228 - 18)} \times 100 = \text{percentage of rosin}$$

Iodine number of bleached shellac	10
" " " rosin	228
" " " mixture	*x*

$$\frac{(x - 10)}{(228 - 10)} \times 100 = \text{percentage of rosin}$$

DETERMINATION OF MOISTURE IN SHELLAC

8. Both orange and bleached shellac give off volatile matter at temperatures approaching 100° C. Bleached shellac alters chemically at these temperatures, losing its solubility in alcohol. For these reasons the usual methods of determining water by heating in the air bath at 100 to 110° C. are not applicable in the analysis of shellac.

SAMPLING

9. Bleached shellac is sold in three forms: as hanks or bars containing approximately 25 per cent of water, as ground bleached in pulverized form with about the same water content, and as bone-dry or kiln-dried shellac. The latter is prepared by drying the ground bleached shellac in the air or in vacuum driers at moderate temperatures. It may contain, depending upon the completeness of the drying and weather conditions, up to 10 per cent or more of water.

10. *Bone-Dry Shellac.*—In sampling bone-dry bleached shellac about 1 lb. should be taken from different parts of the barrel and finely ground by running through a coffee mill. No attempt must be made to sieve it. It is rapidly mixed and transferred to a Mason jar provided with a screw cap and rubber ring seal. The jar should be filled not more than two-thirds full, leaving room for a thorough mixing by shaking the contents. It shall be kept in a cool place and tested as promptly as possible. If too warm the shellac may become partially solidified in which case the lumps must be broken up by shaking the bottle.

11. *Bars or Hanks.*—In sampling bars or hanks it is recommended that a whole hank be taken. It is crushed and ground as rapidly as possible.

12. *Ground Bleached Shellac.*—Ground bleached shellac may be treated as above, bearing in mind that the large amount of moisture present makes rapid handling imperative.

METHOD

13. *Bone-Dry.*—Weigh 5 g. of the finely ground sample in a flat-bottomed dish about 4 in. in diameter and place the dish in a well-ventilated air bath from three to six hours at 38 to 43° C. One or two electric light bulbs provide a convenient source of heat. The temperature should not be allowed to rise above 43° C.

NOTE.—With poorly ventilated ovens the drying may take much longer. Completeness of drying should be ascertained by continuing the treatment to constant weight. The standard is 5 per cent of moisture.

14. *Hanks and Ground Bleached.*—Proceed as in Section 13, but with this one exception, that the dish and its contents are allowed to dry in the air or in a sulfuric acid desiccator over night before it is placed in the air bath. The standard is 25 per cent of moisture.

15. *Orange Shellac.*—Proceed as in the case of Section 13. Orange shellac contains between 1 and 2 per cent of moisture.

TENTATIVE METHOD OF TEST
FOR
DISTILLATION OF GASOLINE, NAPHTHA, KEROSENE, AND SIMILAR PETROLEUM PRODUCTS[1]

Serial Designation: D 86 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED 1923

APPARATUS

Flask. 1. *Flask.*—The Standard 100-cc. Engler flask is shown in Fig. 1, the dimensions and allowable tolerance being as follows:

	CENTIMETERS	INCHES	TOLERANCES, CM.
Diameter of bulb, outside	6.5	2.56	0.2
" " neck, inside	1.6	0.63	0.1
Length of neck	15.0	5.91	0.4
" " vapor tube	10.0	3.94	0.3
Diameter of vapor tube, outside	0.6	0.24	0.05
" " " " inside	0.4	0.16	0.05
Thickness of vapor tube wall	0.1	0.04	0.05

The position of the vapor tube shall be 9 cm. (3.55 in.) ± 3mm. above the surface of the liquid when the flask contains its charge of 100 cc. The tube is approximately in the middle of the neck and set at an angle of 75 deg. (tolerance ± 3 deg.) with the vertical.

Condenser. 2. *Condenser.*—The condenser (Fig. 2) consists of a $\frac{9}{16}$-in. (14.29 mm.) OD No. 20 Stubbs Gage seamless brass tube, 22 in. (55.88 cm.) long. It is set at an angle of 75 deg. from the perpendicular and is surrounded with a cooling bath 15 in. long (38.1 cm.), approximately 4 in. (10.16 cm.) wide by 6 in. (15.24 cm.) high. The lower end of the condenser tube is cut off at an acute angle, and curved downward for a length of 3 in. (7.62 cm.) and slightly backward so as to insure contact with the wall of the graduate at a point 1 to $1\frac{1}{4}$ in. (2.54 to 3.8 cm.) below the top of the graduate when it is in position to receive the distillate.

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[1] The revision in this tentative method consists essentially in the omission of the cotton from the thermometer bulb. Otherwise, the method is practically identical with that published under the serial designation D 86 - 21 T.

Criticisms of this Tentative Method are solicited and should be directed to Mr. Van. H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Shield. 3. *Shield.*—The shield (Fig. 2) is made of approximately 22 gage sheet metal and is 19 in. (48.26 cm.) high, 11 in. (27.94 cm.) long and 8 in. (20.32 cm.) wide, with a door on one narrow side, with two openings, 1 in. (2.54 cm.) in diameter, equally spaced, in each of the two narrow sides, and with a slot cut in one side for the vapor tube. The centers of these four openings are $8\frac{1}{2}$ in. (21.59 cm.)

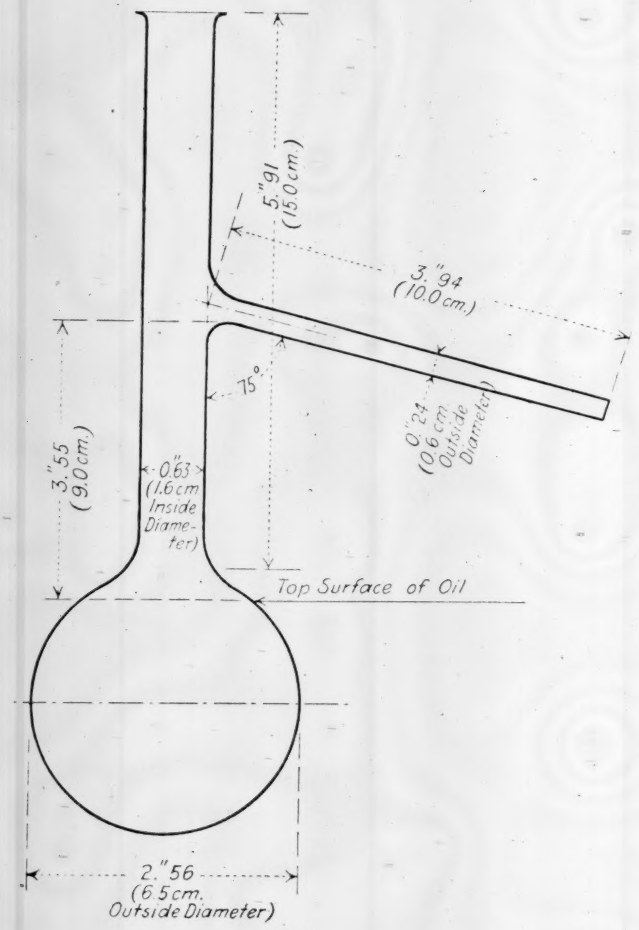
5."91 (15.0 cm.)
3."94 (10.0 cm.)
75°
0."24 (0.6 cm Outside Diameter)
3."55 (9.0 cm.)
0."63 (1.6 cm Inside Diameter)
Top Surface of Oil
2."56 (6.5 cm. Outside Diameter)

FIG. 1

below the top of the shield. There are also three ½-in. (1.27 cm.) holes in each of the four sides with their centers 1 in. (2.54 cm.) above the base of the shield.

4. *Ring Support and Hard Asbestos Boards.*—The ring support is **Support.** of the ordinary laboratory type, 4 in. (10.16 cm.) or larger in diameter, and is supported on a stand inside the shield. There are two hard asbestos boards: One 6 by 6 by ¼ in. (15.24 by 15.24 cm. by 6.35 mm.) with a hole 1¼ in. (3.175 cm.)[1] in diameter in its center, the sides of which shall be perpendicular to the surface; the other, an asbestos board to fit tightly inside the shield, with an opening 4 in. (10.16 cm.) in diameter concentric with the ring support. These are arranged as follows: The second asbestos board is placed on the ring and the first or smaller asbestos board on top so that it may be moved in accordance with the directions for placing the distilling flask. Direct heat is applied to the flask only through the 1¼-in. (3.175 cm.) opening in the first asbestos board.

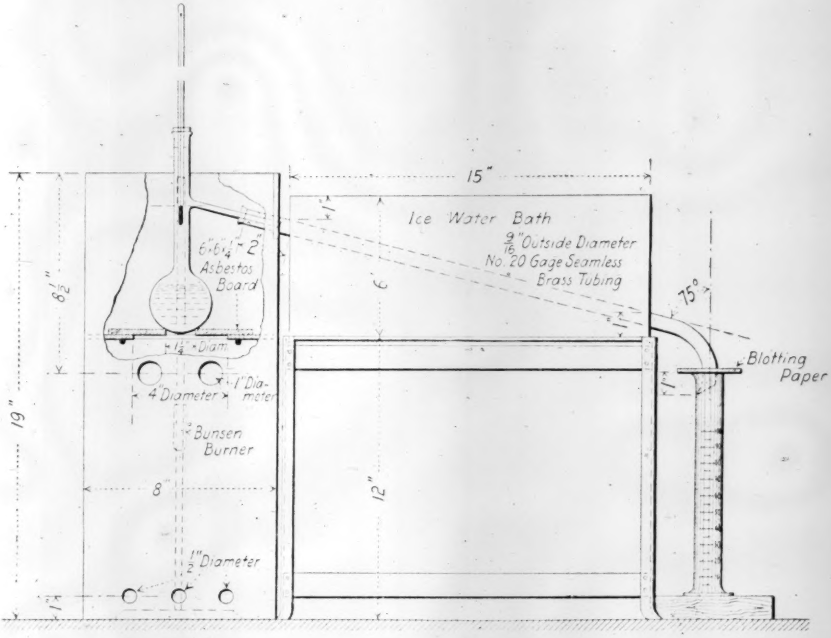
15"
1"
Ice Water Bath
9/16" Outside Diameter
No. 20 Gage Seamless
Brass Tubing
6"
75°
1"
Blotting Paper
1"
12"
6"×6"×¼"×2"
Asbestos
Board
8½"
1¼" Diam.
4" Diameter
1" Diameter
19"
Bunsen
Burner
8"
½" Diameter
1"

FIG. 2

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[1] When distilling petroleum products having an end point above 470° F. (243.34° C.), the hole in the asbestos board shall be 1½ in. (3.81 cm.) in diameter.

5. *Gas Burner or Electric Heater.*—

Heater.

(*a*) *Gas Burner.*—The burner is so constructed that sufficient heat can be obtained to distill the product at the uniform rate specified below. The flame should never be so large that it spreads over a circle of diameter greater than 3½ in. (8.89 cm.) on the under surface of the asbestos board. A sensitive regulating valve is a necessary adjunct, as it gives complete control of heating.

(*b*) *Electric Heater.*—The electric heater, which may be used in place of the gas flame, shall be capable of bringing over the first drop within the time specified below when started cold, and of continuing the distillation at the uniform rate. The electric heater shall be fitted with an asbestos board top ⅛ to ¼ in. (3.175 to 6.35 mm.) thick, having a hole 1¼ in. (3.175 cm.) in diameter in the center. When an electric heater is employed, the portion of the shield above the asbestos board shall be the same as with the gas burner but the part below the board may be omitted.

Thermometer.

6. *Thermometers.*—

(*a*) A.S.T.M. Low Distillation Thermometer shall conform to the following specifications:

Type: Etched stem glass.
Total length: 381 mm.
Stem: Plain front, enamel back, suitable thermometer tubing. Diameter 6 to 7 mm.
Bulb: Corning Normal, Jena 16 III, or equally suitable thermometric glass.
  Length, 10 to 15 mm.
  Diameter, 5 to 6 mm.
Actuating liquid: Mercury.
Range: 30° F. to 580° F., or 0° C. to 300° C.
Immersion: Total.
Distance to 32° F. or 0° C. line from bottom of bulb: 100 to 110 mm.
Distance to 572° F. or 300° C. line from top of stem: 30 to 45 mm.
Filled: Nitrogen gas.
Top finish: Glass ring.
Graduation: All lines, figures and letters clear cut and distinct.
  Scale graduated in 2° F., or 1° C. divisions and numbered every 20° F., or 10° C.; the first and each succeeding 10° F. (5° C.) line to be longer than the others.
Special markings: "A.S.T.M. Low Distillation," serial No. and manufacturer's trade mark etched on the stem.
Accuracy: Error at any point on scale shall not exceed one-half smallest scale division.
Test for permanency of range: After being subjected to a temperature of 560° F., or 290° C., for 24 hours the accuracy shall be within the limit specified.
Points to be tested for certification: 32°, 212°, 400°, 570° F., or 0°, 100°, 200°, 300° C.

(*b*) The A.S.T.M. High Distillation Thermometer shall conform to the following specifications:

Type: Etched stem glass.
Total length: 381 mm.
Stem: Plain front, enamel back, suitable thermometer tubing. Diameter 6 to 7 mm.
Bulb: Corning Normal, Jena 16 III, or equally suitable thermometric glass.
  Length, 10 to 15 mm.
  Diameter, 5 to 6 mm.
Actuating liquid: Mercury.
Range: 30° F. to 760° F., or 0° C. to 400° C.
Immersion: Total.
Distance to 32° F. or 0° C. line from bottom of bulb: 25 to 35 mm.
Distance to 752° F. or 400° C. line from top of stem: 30 to 45 mm.
Filled: Nitrogen gas.
Top finish: Glass ring.
Graduation: All lines, figures and letters clear cut and distinct.
  Scale graduated in 2° F., or 1° C., divisions and numbered every 20° F., or 10° C.; the first and each succeeding 10° F. (5° C.) line to be longer than the others.
Special markings: A.S.T.M. High Distillation. Serial No. and manufacturer's name or trade mark etched on the stem.
Accuracy: Error at any point on scale shall not exceed one smallest scale division up to 700° F., or 370° C.
Test for permanency of range: After being subjected to a temperature of 700° F., or 370° C., for 24 hours the accuracy shall be within the limit specified
Points to be tested for certification: 32°, 212°, 400°, 700° F., or 0°, 100°, 200°, 370° C.

Graduate.

7. *Graduate.*—The graduate shall be of the cylindrical type, of uniform diameter, with a pressed or molded base and a lipped top. The cylinder shall be graduated to contain 100 cc., and the graduated portion shall be not less than 7 in. (17.78 cm.) nor more than 8 in. (20.32 cm.) long. It shall be graduated in single cubic centimeters and each fifth mark shall be distinguished by a longer line. It shall be numbered from the bottom up at intervals of 10 cc. The distance from the 100-cc. mark to the rim shall be not less than 1¼ in. (3.175 cm.) nor more than 1¾ in. (4.445 cm.). The graduations shall not be in error by more than 1 cc. at any point on the scale.

PROCEDURE

Procedure.

8. (*a*) The condenser bath shall be filled with cracked ice,[1] and enough water added to cover the condenser tube. The temperature shall be maintained between 32 and 40° F. (0 and 4.45° C.).

(*b*) The condenser tube shall be swabbed to remove any liquid remaining from the previous test. A piece of soft cloth attached to a cord or copper wire may be used for this purpose.

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[1] Any other convenient cooling medium may be used.

(*c*) One hundred cubic centimeters of the product shall be measured in the 100-cc. graduated cylinder at 55 to 65° F. (12.78 to 18.33° C.) and transferred directly to the Engler flask. None of the liquid shall be permitted to flow into the vapor tube.

(*d*) The thermometer[1] provided with a cork shall be fitted tightly into the flask so that it will be in the middle of the neck and so that the lower end of the capillary tube is on a level with the inside of the bottom of the vapor outlet tube at its junction with the neck of the flask.

(*e*) The charged flask shall be placed in the $1\frac{1}{4}$-in. (3.175-cm.) opening in the 6 by 6-in. (15.24 by 15.24-cm.) asbestos board with the vapor outlet tube inserted into the condenser tube. A tight connection may be made by means of a cork through which the vapor tube passes. The position of the flask shall be so adjusted that the vapor tube extends into the condenser tube not less than 1 in. (2.54 cm.) nor more than 2 in. (5.08 cm.).

(*f*) The graduated cylinder used in measuring the charge shall be placed, without drying, at the outlet of the condenser tube in such a position that the condenser tube shall extend into the graduate at least 1 in. (2.54 cm.) but not below the 100-cc. mark. Unless the temperature is between 55 and 65° F. (12.78 and 18.33° C.) the receiving graduate shall be immersed up to the 100-cc. mark in a transparent bath maintained between these temperatures. The top of the graduate shall be covered closely during the distillation with a piece of blotting paper or its equivalent, cut so as to fit the condenser tube tightly.

Distillation. 9. When everything is in readiness, heat shall be applied at a uniform rate, so regulated that the first drop of condensate falls from the condenser in not less than 5 nor more than 10 minutes. When the first drop falls from the end of the condenser the reading of the distillation thermometer shall be recorded as the *initial boiling point.* The receiving cylinder shall then be moved so that the end of the condenser tube shall touch the side of the cylinder. The heat shall then be so regulated that the distillation will proceed at a uniform rate of not less than 4 nor more than 5 cc. per minute. The reading of the distillation thermometer shall be recorded when the level of the distillate reaches each 10-cc. mark on the graduate.

After the 90-per-cent point has been recorded, the heat may be increased because of the presence of the heavy ends which have high boiling points. However, no further increase of heat should be applied after this adjustment. The 4 to 5-cc. rate can rarely be maintained from the 90-per-cent point to the end of the distillation, but in no case should the period between the 90-per-cent and the end point be more than five minutes.

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[1] For products having an initial boiling point of 212° F. (100° C.) or higher, the High Distillation Thermometer shall be used; for all other products, the Low Distillation Thermometer shall be used.

The heating shall be continued until the mercury reaches a maximum and starts to fall consistently. The highest temperature observed on the distillation thermometer shall be recorded as the *maximum temperature* or end point. Usually this point will be reached after the bottom of the flask has become dry.

The total volume of the distillate collected in the receiving graduate shall be recorded as the *recovery*.

The cooled residue shall be poured from the flask into a small cylinder graduated in 0.1 cc., measured when cool and the volume recorded as *residue*.

The difference between 100 cc. and the sum of the recovery and the residue shall be calculated and recorded as *distillation loss*.

ACCURACY

10. With proper care and attention to detail, duplicate results obtained for initial boiling point and maximum temperature, respectively, should not differ from each other by more than 6° F. (3.33° C.). **Accuracy.**

TENTATIVE METHODS OF TEST
FOR
VISCOSITY OF PETROLEUM PRODUCTS AND LUBRICANTS[1]

Serial Designation: D 88 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1921; Revised, 1923

Choice of Instrument.

1. (*a*) Viscosity shall be determined by means of the Saybolt Universal or Saybolt Furol Viscosimeter.

(*b*) In general, the Saybolt Universal Viscosimeter shall be used for lubricants and the Saybolt Furol Viscosimeter for fuel oils and other oils of similar viscosity.

(*c*) The Saybolt Universal Viscosimeter shall not be used for times of flow less than 32 seconds.

Table I.—Dimensions of Oil Tubes

Dimensions	Saybolt Universal Viscosimeter			Saybolt Furol Viscosimeter		
	Minimum, cm.	Normal, cm.	Maximum, cm.	Minimum, cm.	Normal, cm.	Maximum, cm.
Inside diameter of outlet tube	0.1750	0.1765	0.1780	0.313	0.315	0.317
Outside diameter of outlet tube at lower end	0.28	0.30	0.32	0.40	0.43	0.46
Length of outlet tube[1]	1.215	1.225	1.235	1.215	1.225	1.235
Height of overflow rim above bottom of outlet tube[1]	12.40	12.50	12.60	12.40	12.50	12.60
Diameter of container[1]	2.955	2.975	2.995	2.955	2.975	2.995
Depth of cylindrical part of container[1]	8.8	....	....	8.8	....	....

[1] This dimension is identical in the Saybolt Universal and the Saybolt Furol instruments.

I. APPARATUS

Viscosimeters.

2. (*a*) The Saybolt viscosimeters (see Fig. 1) are made entirely of metal. The oil tube, *A*, is fitted at the top with an overflow cup, *B*, and the tube is surrounded by a bath. At the bottom of the oil tube is a small outlet tube through which the oil to be tested flows into a receiving flask, Fig. 2, whose capacity at 20° C. (68° F.) to a mark on its neck is 60, ±0.15, cc. The lower end of the outlet tube is enclosed by a larger tube, which when stoppered by a cork, *C*, acts as a closed air chamber and prevents the flow of oil through the outlet tube until the cork is removed and the test started. A looped string

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Van. H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

may be attached to the lower end of the cork as an aid to its rapid removal. The temperatures in the oil tube and in the bath are shown by thermometers. The bath may be heated by any suitable means. The oil tube shall be thoroughly cleaned, and all oil entering the oil tube shall be strained through a 60-mesh wire strainer. A stop watch shall be used for taking the time of flow of the oil and a pipette shall be used for draining the overflow cup.

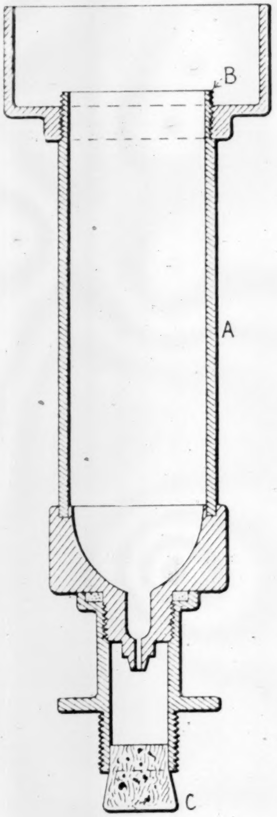

FIG. 1.—Sectional View of Standard Oil Tube.

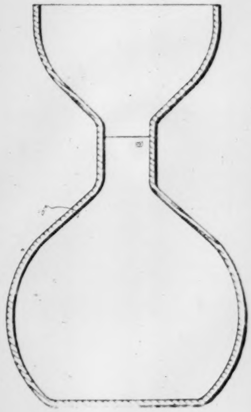

FIG. 2.—Receiving Flask.

Oil Tube.

(*b*) The oil tubes, which may be standardized by the U. S. Bureau of Standards, shall conform to the dimensions given in Table I.

Thermometers.

(*c*) The bath and oil tube thermometers shall conform to the following requirements. They cover two sets of 4 thermometers each, one set being graduated in Fahrenheit degrees and the other set in Centigrade degrees, the ranges being chosen to include the temperatures commonly used in testing.

Type: Etched stem, glass.

Liquid: Mercury.

Ranges and Subdivisions:

Range 66– 80° F., subdivision in 0.2° F. for tests at 77° F.
" 94–108° F., " 0.2° F. " 100° F.
" 120–134° F., " 0.2° F. " 122 and 130° F.
" 204–218° F, " 0.2° F. " 210° F.

or

Range 19–27° C., subdivision in 0.1° C. for tests at 25° C.
" 34–42° C., " 0.1° C. " 40° C.
" 49–57° C., " 0.1° C. " 50° C.
" 95–103° C., " 0.1° C. " 100° C.

Total Length: 252 to 256 mm. (9.92 to 10.08 in.).

Stem: Plain front, enamel back, suitable thermometer tubing. Diameter, 6 to 7 mm. (0.236 to 0.275 in.).

Bulb: Corning normal or equally suitable thermometric glass.
Length, 25 to 35 mm. (1.0 to 1.4 in.).
Diameter, not less than 5 mm (0.197 in.) and not greater than that of stem.

Distance to Lowest Specified Graduation from Bottom of Bulb: 135 to 150 mm. (5.3 to 5.9 in.).

Distance to Highest Specified Graduation from Top of Stem: 20 to 35 mm. (0.8 to 1.4 in.).

Contraction Chamber: To be of long narrow type, top to be not more than 60 mm. (2.36 in.) above bottom of bulb, mercury to stand in contraction chamber at 32° F. (0° C.).

Expansion Chamber: To permit heating the thermometer 90° F. (50° C.) above highest temperature on scale, and in all cases to permit heating to 212° F. (100° C.).

Filling above Mercury: Nitrogen gas.

Top Finish: Glass ring.

Graduation: All lines, figures and letters clear cut and distinct. The first and each succeeding 1° F. or 0.5° C. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 2° F. or 1° C.

Immersion: Total.

Special Marking: "A.S.T.M." Viscosity test points to be numbered in full figures and in red, other graduations and figures in black. A serial number and the manufacturer's name or trade mark shall be etched on the stem.

Scale Error: The error at any point of the scale shall not exceed 0.2° F. (0.1 C.)

Standardization: The thermometers are to be standardized for the condition of total immersion.

Case: Each thermometer shall be supplied in a suitable case on which shall appear the marking, "A.S.T.M., Saybolt Viscosimeter Thermometer" and the range.

II. TEMPERATURE OF TESTING

Temperature. 3. (*a*) With the Saybolt Universal viscosimeter, determinations shall be made at 100° F. (37.8° C.), 130° F. (54.4° C.) or 210° F. (98.9° C.).

(*b*) With the Saybolt Furol viscosimeter, determinations shall be made at 122° F. (50° C.).

(*c*) Viscosities shall be expressed as .... seconds, Saybolt Universal (or Saybolt Furol), being the time in seconds for the delivery of 60 cc. of oil.

(*d*) Fuel oils and other oils of similar viscosity showing a time of less than 25 seconds, Saybolt Furol, at 122° F., shall be tested on the Saybolt Universal at 122° F. Oil showing a time of less than 32 seconds, Saybolt Universal, at 122° F., shall be measured in the Saybolt Universal at 100° F. (37.8° C.). These methods of test do not apply to fuels having a viscosity at 100° F. of less than 32 seconds Saybolt Universal, which are not considered to be fuel oils.

III. PROCEDURE

Procedure.

4. The bath shall be held constant within 0.25° F. (0.14° C.) at such a temperature as will maintain the desired temperature in the oil tube. For viscosity determinations at 100, 122 and 130° F., oil or water may be used as the bath liquid. For viscosity determinations at 210° F., oil shall be used as the bath liquid. Viscosity determinations shall be made in a room free from draughts, and from rapid changes in temperature. All oil introduced into the oil tube either for cleaning or for test shall first be passed through the strainer.

To make the test, heat the oil to the necessary temperature and clean out the oil tube. Pour some of the oil to be tested through the cleaned tube. Insert the cork stopper into the lower end of the air chamber at the bottom of the oil tube, sufficiently to prevent the escape of air, but not to touch the small outlet tube.

Heat the oil to be tested, outside the viscosimeter, to slightly below the temperature at which the viscosity is to be determined, and pour it into the oil tube until it ceases to overflow into the overflow cup. By means of the oil-tube thermometer, keep the oil in the oil tube well stirred and also stir well the liquid in the bath. It is extremely important that the temperature of the bath be maintained constant during the entire time consumed in making the test. When the temperature of the bath and of the oil in the oil tube are constant and the oil in the oil tube is at the desired temperature, withdraw the oil tube thermometer; quickly remove the surplus oil from the overflow cup by means of a pipette so that the level of the oil in the overflow cup is below the level of the oil in the tube proper; place the 60-cc. flask, Fig. 2, in position so that the stream of oil from the outlet tube will strike the neck of the flask so as to avoid foam. Snap the cork from its position, and at the same instant start the stop watch. Stir the liquid in the bath during the run and carefully maintain it at the previously determined proper temperature. Stop the watch when the bottom of the meniscus of the oil reaches the mark on the neck of the receiving flask.

The time in seconds for the delivery of 60-cc. of oil is the Saybolt Universal (or Saybolt Furol) viscosity of the oil at the temperature at which the test was made.

TENTATIVE METHOD OF TEST
FOR
COLOR OF LUBRICATING OILS BY MEANS OF UNION COLORIMETER[1]

Serial Designation: D 155 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

I. APPARATUS

Scope. 1. The color of all lubricating oils shall be determined by means of the Union Colorimeter.

Apparatus. 2. (*a*) The Union Colorimeter, Fig. 1, shall consist of a box, *a*, glass color standards, a glass jar, a light shield, *b*, and a daylight lamp, *c*.

(*b*) The box, *a*, Fig. 1, shall have an interior finish of dull black, and may be constructed of metal or wood, approximately 18 in. in length and $1\frac{1}{2}$ in. in depth in inside dimensions, the observation end being $2\frac{1}{8}$ in. in width and the end next to the source of light 3 in. in width.

A transverse vertical partition having a circular hole in the end $\frac{1}{2}$ in. in diameter shall be placed $1\frac{1}{8}$ in. from the observation end of the box. In the opposite end shall be mounted a rectangular piece of pure white opal glass, approximately $3\frac{1}{4}$ by $1\frac{3}{4}$ by $\frac{1}{16}$ in., which shall be ground or etched on the inner side to diffuse light rays. Approximately $2\frac{1}{8}$ in. from the light end of the box shall be a second vertical partition 1 in. in thickness having two openings about $\frac{3}{4}$ in. in diameter at light-source side and about $\frac{9}{16}$ in. in diameter on the opposite side, symetrically located in regard to the vision line. In case the standards are not mounted, a vertical partition shall be placed approximately $3\frac{1}{4}$ in. from the light-source end, having a thickness of $\frac{1}{8}$ in., and shall have two circular openings $\frac{9}{16}$ in. in diameter and $1\frac{1}{2}$ in. apart. Extending from the opal glass to this partition along the horizontal axis of the box shall be a vertical partition approximately $\frac{1}{8}$ in. in thickness for a distance of $1\frac{5}{8}$ in., and then continuing with a thickness of $\frac{7}{8}$ in. until abutting against the transverse partition which in conjunction serves to divide the light end of the box into two compartments. In the top of the box, immediately over the centers of these two compartments, there shall be circular holes of such a size to accommodate the standard jar and 4-oz. oil sample bottles. In the top of the box, directly above the $\frac{3}{4}$ in. opening in the left side of the second partition, there shall be an opening or slot suitable for placing the glass color standards in a vertical position

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van. H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

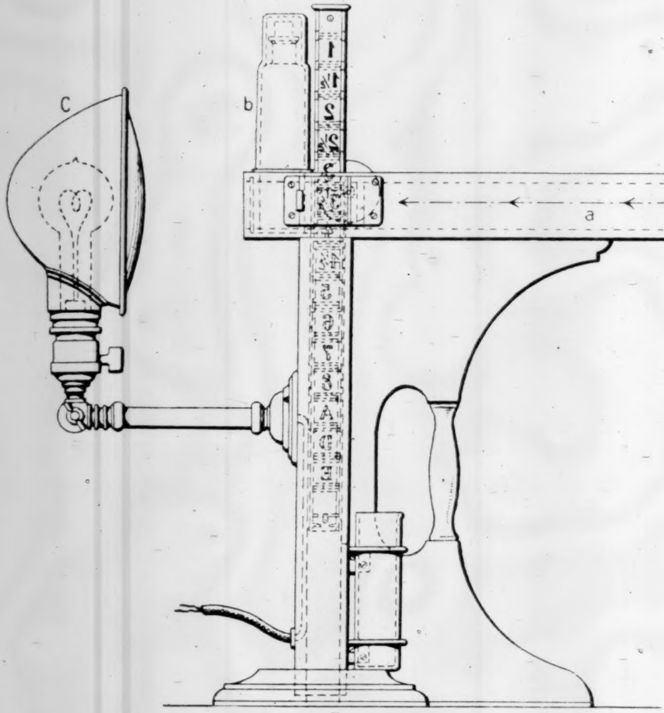

FIG. 1.—Union Colorimeter

in the opening in the partition. In case the color standards are not mounted in a magazine, this opening shall be provided with a sliding cover so that all light may be excluded. In case all the glass standards are mounted in a magazine, suitable arrangements shall be made for this magazine to be raised or lowered through the opening provided for the glass standards, and when such a magazine is used, a hole may be located in the left side of the box through which the numbers of the mounted glass standards may be read. For convenience, numbers may be stamped on the magazine as mirror images, and a swinging mirror may be provided on the side of the box so that the operator may read the numbers on the magazine from the front of the instrument.

Color Standards. (*c*) The glass color standards shall be 15 in number as specified in Table I. These glasses may be kept separately or for convenience may be mounted in a magazine. If so mounted, there shall be a blank opening provided in the magazine so that 2 bottles of oil may be compared in the colorimeter as well as a sample of oil and the glass color standards. The glass color standards shall be not less than $\frac{5}{8}$ in. across.

Glass Test Jar. (*d*) The standard glass jar, Fig. 2, shall be a true cylinder of clear colorless glass. The internal diameter shall be not less than 32.5 mm. nor more than 33.5 mm. The thickness of the wall shall be 1.75 mm. ±0.25 mm. The height of the cylinder shall be 5 in. $\pm\frac{1}{4}$ in.

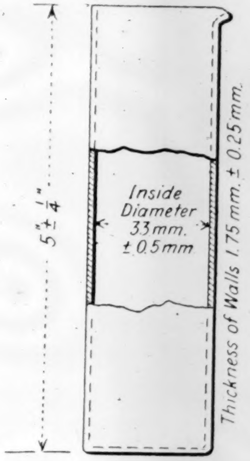
5"±¼"
Inside Diameter 33mm. ±0.5mm
Thickness of Walls 1.75 mm. ± 0.25 mm.

FIG. 2.—Standard Glass Jar for Use With Union Colorimeter

Light Shield. (*e*) The light proof cover, *b*, shall be of any suitable material. It shall be dull black on the inside and of such size as to completely shield all light from the tops of the cylinders, or oil sample bottles, when they are in place in the colorimeter.

Artificial Daylight Lamp. (*f*) The artificial daylight lamp, *c* (Fig. 1), may for convenience be fastened to the base supporting the box. It shall consist of a 50-watt *C2* national mazda lamp, fitting into a socket on a swivel fitted with a parabolic metal reflector. The inside of this reflector shall be brightly silvered at all times with bright aluminum paint or brightly polished silver or nickel. In the front of the reflector shall be mounted a dished, but not lenticular, glass color screen of such composition and color as, in conjunction with the *C2* mazda lamp, will yield by spectrum analysis a light closely approximating northern daylight. When in normal position, the color screen shall be 4 in. from the white opal glass.

In case electric current is not available, the colorimeter may be used by exposing the opal glass to northern daylight with no colored objects in the immediate foreground, but the artificial daylight lamp shall be required in referee work.

II. PROCEDURE

Procedure. 3. The oil, when examined, shall be at room temperature unless its cloud point is above the temperature of the room, in which case the oil shall be heated to a temperature of not more than 10° F. above its cloud point. The oil to be examined may be observed in the ordinary 4-oz. sample bottle, but in referee work a standard jar shall be used. The jar shall be placed in the right-hand compartment while in the other compartment shall be placed a 4-oz. sample bottle of distilled water. The jar and bottle shall be covered with the shield, and the artificial daylight lamp lighted. One at a time, the glass color standards shall be placed between the bottle of distilled water and the eye,

TABLE I.—GLASS COLOR STANDARDS OF UNION COLORIMETER

A.S.T.M. Color Numbers	Union Petroleum Co. Designations	National Petroleum Association Color Numbers (1915)	National Petroleum Association Names	Lovibond Analysis		
				Red 200 Series	Yellow 510 Series	Blue 1180 Series
1	*G*	No. 1 N.P.A.	Lily White	0.12	2.4	....
1½	*H*	No. 1½ N.P.A.	Cream White	0.60	8.0	....
2	*I*	No. 2 N.P.A.	Extra Pale	2.5	26.0	....
2½	*J*	No. 2½ N.P.A.	Ex. Lemon Pale	4.6	27.0	....
3	*K*	No. 3 N.P.A.	Lemon Pale	6.9	32.0	....
3½	*L*	[a]	Ex. Orange Pale	9.4	45.0	..
4	*M*	No. 4 N.P.A.	Orange Pale	14.0	50.0	0.55
4½	*N*	No. 4½ N.P.A.	Pale	21.0	56.0	0.55
5	*O*	No. 5 N.P.A.	Light Red	35.0	93.0	....
6	*P*	No. 6 N.P.A.	Dark Red	60.0	60.0	0.55
7	*Q*	*Q*	Claret Red	60.0	106.0	1.8
8	*R*	[b]		166.0	64.0	....
A	*A*	Cylinder Oil Ex. Light Filtered		10.2	29.0	....
D	*D*	Cylinder Oil Light Filtered		21.0	31.0	....
E	*E*	Cylinder Oil Medium Filtered		89.0	56.0	....

[a] N. P. A. Color of 1915 changed slightly to make 3½ more nearly midway between 3 and 4.

[b] A New Color.

in the slot provided for them, until the nearest match possible is obtained. In case the standards are not mounted in a magazine, the slide on the top of the box shall be pressed against the glass standard to keep out light, while making an observation.

Cylinder Oils.

4. Filtered cylinder oils and other oils that are darker than No. 8 color (Table I) shall be diluted with water white kerosene, the color of which is not darker than No. 21 as determined in accordance with the Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (Serial Designation: D 156 – 23 T) of the American Society for Testing Materials,[1] a mixture of exactly 15 per cent by volume of oil, and 85 per cent by volume of kerosene being used in all cases. This mixture shall then be compared with the three cylinder oil standards, or optionally with the standards ranging from No. 1 to No. 8, inclusive. The daylight lamp may be brought closer to the opal glass in determining the darker colors.

The numbers or letters, designating the color of all oils that have been diluted to make the determination, shall be followed by the designation "Dil."

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[1] See p. 682.

TENTATIVE METHOD OF TEST
FOR
COLOR OF REFINED PETROLEUM OIL BY MEANS OF SAYBOLT CHROMOMETER[1]

Serial Designation: D 156 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

Scope. 1. The color of all refined oils (naphthas, kerosenes, etc.) shall be determined by means of the Saybolt Chromometer.

I. APPARATUS

Glass Tubes. 2. (*a*) The Saybolt Chromometer shall consist of two glass tubes having an internal diameter of not less than 14 mm. nor more than 16 mm. One glass tube, 20 in. in length, shall be permanently closed at one end with a colorless, plano glass disk, and be mounted in a suitable metal collar, provided with a small pet-cock, for the purpose of draining the tube. This glass tube shall be graduated in $\frac{1}{8}$-in. divisions, numbered in inches. The other tube, 19 in. in length, shall be open at both ends, one end being mounted in a suitable metal collar which will hold the color standards and a black metal diaphragm with a circular aperture 12 mm. in diameter. The mounting of this tube shall be such as to give equal length to both tubes. The tubes shall be mounted vertically and shall be covered at their upper end with a removable diaphragmed metal cap about 1 in. in length and of sufficient diameter to easily slip over the end of the tubes. The circular diaphragm aperture shall be 14 mm. in diameter.

Optical System. (*b*) The instrument shall be provided with a suitable optical head consisting of prisms and eyepiece. The prisms shall be of a suitable form, matched in their refracting angles and areas, and so mounted as to avoid possibility of disarrangement. They shall be so arranged that the light rays passing through the tubes shall be deflected to a central aperture which is viewed by the eyepiece. The arrangement shall be such as to provide a circular field of vision, the two halves of which are illuminated by the light transmitted by the sample and the color standard, respectively.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van. H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Illumination.

3. (*a*) Light shall be provided by means of a reflecting mirror with a finely frosted surface set at a suitable angle and so arranged that the reflected light shall pass through suitable openings and through the glass tubes in parallel rays; or it shall be provided by projecting a diffused light directly up through the tubes, from the base of the instrument.

Light Source.

(*b*) The light shall be supplied by an artificial daylight lamp so arranged as to project a diffused light on the reflecting mirror or directly up through the tubes.

TABLE I.—COLOR STANDARDS, CORRESPONDING TO HEIGHTS OF OIL

	Saybolt Chromometer			Saybolt Chromometer	
Number of Disks	Height of Oil, In.	Color Shade	Number of Disks	Height of Oil, In.	Color Shade
One.........	20.0	+25	Two........	5.50	+4
One.........	18.0	+24	Two........	5.25	+3
One.........	16.0.	+23	Two........	5.00	+2
One.........	14.0	+22	Two........	4.75	+1
One.........	12.0	+21	Two........	4.50	0
One.........	10.75	+20	Two........	4.25	−1
One.........	9.50	+19	Two........	4.00	−2
One.........	8.25	+18	Two........	3.75	−3
One.........	7.25	+17	Two........	3.625	−4
One.........	6.25	+16	Two........	3.50	−5
Two........	10.50	+15	Two........	3.375	−6
Two........	9.75	+14	Two........	3.25	−7
Two........	9.00	+13	Two........	3.125	−8
Two........	8.25	+12	Two........	3.00	−9
Two........	7.75	+11	Two........	2.875	−10
Two........	7.25	+10	Two........	2.75	−11
Two........	6.75	+9	Two........	2.625	−12
Two........	6.50	+8	Two........	2.50	−13
Two........	6.25	+7	Two........	2.375	−14
Two........	6.00	+6	Two........	2.25	−15
Two........	5.75	+5	Two........	2.125	−16

Daylight Lamp.

(*c*) The artificial daylight lamp shall consist of a *C2* national mazda lamp, the rays of light from which shall pass through a glass color screen of such composition and color, as, in conjunction with the *C2* national mazda lamp, will yield by spectrum analysis a light closely approximating northern daylight.

In case electric current is not available, the chromometer may be used by exposing the mirror to northern daylight with no colored objects in the immediate foreground, but the artificial daylight lamp shall be required in referee work.

4. The color standards shall consist of suitable glass disks.

II. PROCEDURE

Illumination.

5. (*a*) The Saybolt Chromometer shall be assembled and the light source so adjusted that a diffused light, with absence of glare or shadow, shall be projected on the reflecting mirror, or projected directly through the tubes from the base of the instrument, thereby eliminating the mirror. Light from all other sources shall be excluded.

Filling Oil Tube.

(*b*) The oil tube shall be cleaned by rinsing with some of the oil to be tested, care being taken to allow the tube to drain thoroughly. The pet-cock on the oil tube shall then be closed and the tube shall be filled with the oil to be tested to a height of 10.5 in.

Determination of Color.

(*c*) The measurement of the color shall be made by using two standard color disks when the oil is darker than the two disks and by using one disk when the oil is lighter than the two disks. After determining the number of disks to be used and with the proper number in place in the color standard, the oil tube shall contain a sufficient height of oil for the color of the oil to be decidedly darker than the color standard, additional oil being added if necessary. The oil shall then be drawn off slowly by means of the pet-cock until the oil appears slightly darker than the color standard. The oil shall then be drawn down to the nearest height corresponding to a standard color shade as shown in Table I. If the color of the oil observed through the eyepiece is still darker than the color standard, the oil shall be drawn down to the next height given in Table I and examined again. This operation shall be continued until the oil and color standard match or show questionable differences. The column of oil shall be lowered one shade more and if the oil is unmistakably lighter than the color standard, the previous color shade shall be recorded as the Saybolt Chromometer Color.

APPENDIX

The following examples of the procedure are given:

USING 1 DISK	
Oil darker at height of	16 in.
Oil darker at height of	14 in.
Oil questionable at height of	12 in.
Oil lighter at height of	10.75 in.
Color is	+21

USING 2 DISKS	
Oil darker at height of	4.5 in.
Oil darker at height of	4.25 in.
Oil questionable at height of	4.0 in.
Oil lighter at height of	3.75 in.
Color is	−2

TENTATIVE METHOD OF TEST
FOR
STEAM EMULSION OF LUBRICATING OILS[1]

Serial Designation: D 157 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Scope. 1. This method shall be used on all oils when an emulsion, demulsibility or emulsification test is required. This method is commonly used for turbine oils and may be used for other lubricating oils.

Description. 2. The Modified Resistance to Emulsification Number (A.S.T.M. R.E.) is the number of minutes required for an oil to separate when emulsified and separated under definitely prescribed conditions.

I. APPARATUS

Steam Generator. 3. The steam generator shall be made of either metal or glass of at least one-liter capacity, capable of withstanding the heat necessary for continued use in the production of steam. It shall be fitted with three outlets with suitable connections for rubber tubing. In case of a metal generator, a large opening for filling and a suitable water gage shall be a necessary part of the apparatus.

Baths. 4. The baths shall be either of metal or glass, with a capacity of 3 to 3½ liters and a depth of 7½ to 9 in. A good quality battery jar or beaker is entirely satisfactory. A glass bath shall be used for emulsification and a metal or glass bath may be used for the separation.

Source of Heat. 5. Heat for the steam generator shall be supplied by a suitable gas burner or electric hot plate. The separating bath may be heated by any convenient means, including an auxiliary steam line as shown in Fig. 1.

Oil Container. 6. The oil container shall be a 25 by 200-mm. test tube graduated from zero or from 10 to 50 cc. in cubic centimeters, each even 5-cc. line to encircle the tube.

Steam Piping. 7. The steam piping or the steam delivery tube shall consist of a piece of thin-wall glass tubing, not less than 2.3 nor more than 2.7 mm. in inside diameter and 12 in. in length. The steam pipe shall be cut off diagonally at an angle of 30 deg. with the axis of the tube at the discharge orifice and shall be bent at right angles 10 in. from the discharge orifice.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van. H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Accessories. 8. Accessories shall consist of:

(*a*) Suitable wooden or metal frames or holders for holding all containers in a vertical position in the baths.

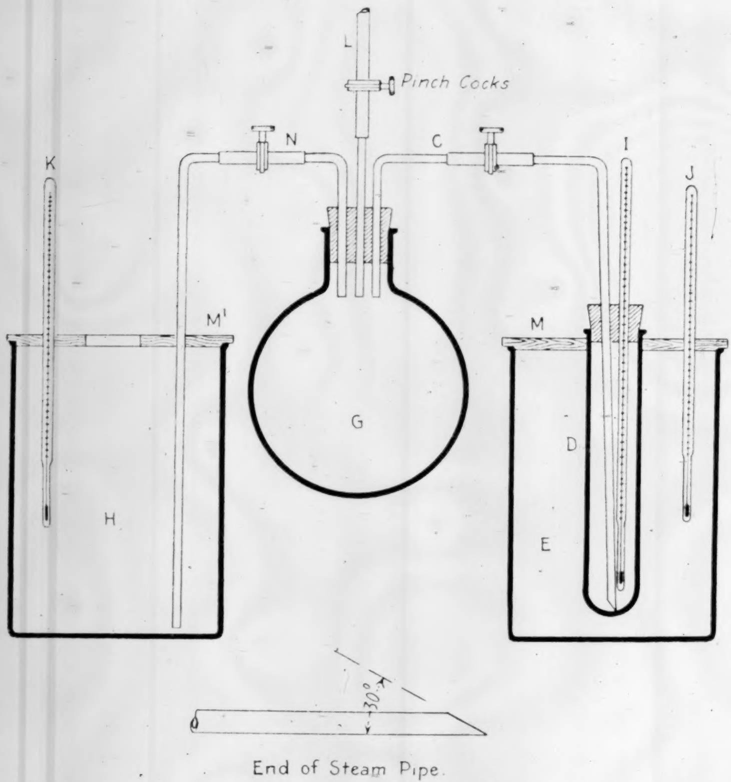

FIG. 1.—Apparatus for Test for Resistance to Emulsion. Self-Generating Steam Supply

(*b*) Thermometers for the separating and emulsifying baths (floating type thermometers of suitable range);

(*c*) Thermometers for the oil container tube (engraved-stem type, of suitable range, graduated in 1° F., 5 to 7 mm. in diameter);

(*d*) Corks, rubber tubing and screw pinch cocks.

II. PROCEDURE

Preparation. 9. The apparatus shall be assembled as shown in Fig. 1. The steam generator shall be filled one-half full of water and heat applied.

The baths shall be filled with 3 liters ±60 cc. of water. The temperature in the separating bath shall be raised to and maintained at 200 to 203° F.

NOTE.—Care must be taken if glass battery jars are used, as direct heating by flame or electric hot point may cause breakage. Use of steam in this connection insures against breakage.

The temperature of the emulsifying bath shall be brought to not less than 67° F., nor more than 78° F. at the start of the test, and is not controlled thereafter. Twenty cubic centimeters of the oil to be tested shall be measured in the oil container at room temperature and the latter placed in the holder of the emulsifying bath. The steam pipe, or delivery tube, shall be connected to the steam generator with suitable rubber tubing, and screw pinch-cocks placed as show in Fig. 1.

Care shall be taken to see that the apparatus particularly the oil container, oil container thermometer and the steam delivery tube are *chemically clean* before using. Care shall also be taken to prevent any foreign materials from entering the steam generator as any contamination of the steam renders the test valueless.

Emulsification.

10. The steam delivery tube line shall be steamed out until all condensation disappears. A cork having two openings, with the thermometer in one, shall be placed in the mouth of the oil container. The thermometer shall be adjusted so that the bottom of the bulb is $\frac{3}{4}$ to 1 in. from the bottom of the oil container. The steam delivery tube shall be inserted through the second opening in the cork (Note.—This fitting shall be loose.) so that the end of the steam delivery tube shall touch the center of the bottom of the oil container. Steam shall be admitted at a rate that will maintain the temperature of the oil, as shown on the thermometer in the oil container, between 190 and 195° F.

NOTE.—The usual time necessary for the temperature of the oil to come to this point is 45 to 75 seconds, depending on its character.

This control shall be effected by manipulation of the pinch-cocks on the steam delivery line and steam exhaust line from the steam generator. The steam supply shall be sufficient at all times to cause a generous discharge from the exhaust line. Steaming shall be continued until the volume of condensed steam and oil in the oil container tube is 40 cc. ±3 cc. The time required for this operation shall be 4 to 6.5 minutes, depending on the quality of the oil, altitude, etc. If condensed water amounts to 20 cc. in less than 4 minutes, it shall be taken as an indication of wet steam or incomplete steaming out of the line and the test shall be re-run.

NOTE.—The apparent volume in the tube near the end of the steaming operation is approximately 12 to 15 cc. greater than the actual volume due to displacement caused by steam, thermometer and steam delivery tube.

Separation. 11. The steam delivery tube shall be withdrawn as soon as the required volume is obtained. The oil container shall be transferred immediately to the separating bath which shall be maintained at 200 to 203° F. It is extremely important that the temperature of the separating bath be maintained within the given limits. A stop watch shall be started at the instant of withdrawal of the steam delivery tube. The cork containing the thermometer shall be removed after the oil container and contents have been placed in the separating bath. The contents of the oil container shall be examined every 30 seconds, and the volume of the separated oil layer shall be recorded. This examination shall be made by withdrawing the oil container and its contents from the separating bath, and reading the volumes.

NOTE.—This operation shall not require over five seconds.

No differentiation shall be made between clear and turbid oil.

This reading operation shall be continued until 20 cc. of oil have separated. In cases where the 20-cc. oil layer does not separate in 20 minutes, the test shall be discontinued at this point.

In cases where the interface between more-or-less clear oil and the emulsion is not a clear, straight horizontal line, the position of such a line is carefully estimated to the nearest 0.5 cc.

If, at the end of 20 minutes, there is not a well-defined horizontal interface, then, and then only, the contents of the oil container may be stirred for two seconds with a clean glass rod to obtain a better line of demarcation.

Interpretation. 12. In interpreting results, the assumption shall be made that the rate of emulsion separation is directly proportional to the Resistance to Emulsification of the tested oil. In order to establish a basis for comparison, a definite value of one shall be assigned to an oil which, under conditions of the test, separates completely from emulsion in one minute. This is equivalent to an emulsion separation rate of 0.33 cc. per second or 20 cc. per minute.

NOTE.—The expansion of the oil at the higher temperature is disregarded, so when the separation of the oil is complete, as regards the interface between the oil and emulsion layers, the volume of separated oil will always be more than 20 cc. This in no way interferes with the reproducibility of results, and the time shall be recorded when 20 cc.—and not necessarily all—of the oil have separated, when this occurs in less than 20 minutes.

13. Results shall be reported, in minutes and half minutes, of the time necessary for complete (20 cc.) oil separation. The time in minutes and half minutes shall be reported as the R.E. Number, A.S.T.M. Method. In cases where the required volume shall not have separated in 20 minutes, the oil shall be reported as having an R.E. Number, A.S.T.M. Method, of 20 plus. If duplicate determinations vary by more than one minute, a third test shall be made and the average of the three tests reported. **A.S.T.M. R.E. Number.**

NOTE.—Oils which emulsify separate into three layers without exception: top, clear or turbid oil; middle, lacy or creamy emulsion; bottom, clear or milky water. The A.S.T.M. R.E. Number is derived from the top layer.

14. With care and proper attention to details, duplicate determinations of the R.E. Number, A.S.T.M. Method, should not differ by more than 0.5. **Reproducibility.**

TENTATIVE METHOD OF TEST
FOR
FLASH AND FIRE POINTS BY MEANS OF OPEN CUP[1]

Serial Designation: D 92 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923

Scope. 1. The open cup flash and fire test on all products except fuel oils and those having an open cup flash below 175° F. shall be determined in the Cleveland Open Cup.

APPARATUS

Flash Cup. 2. The cup shall be heated by contact with a metal plate $\frac{1}{4}$ in. (0.635 cm.) in thickness and 6 in. (15.24 cm.) in width. The plate shall be of brass, cast iron, wrought iron or steel. In the center of the plate there shall be a plane depression $\frac{1}{32}$ in. (0.079 cm.) in depth, and of just sufficient diameter to fit the cup. There shall be a circular opening $2\frac{3}{16}$ in. (5.50 cm.) in diameter, cut through the plate, centering with the center of the above-mentioned depression. The plate shall be covered with a sheet of hard asbestos board $\frac{1}{4}$ in. in thickness, and of the same shape as the metal plate. There shall be cut in the center of the asbestos board a circular hole just filling the cup. Heat may be supplied from any convenient source. The use of a gas burner, electric heater, or alcohol lamp is permitted, but under no circumstances are products of combustion or free flame allowed to come up around the cup. The source of heat shall be centered under the opening in the plate and shall be of a type that will not produce local superheating. If a flame heater is used, it may be protected from drafts or excessive radiation by any suitable type of shield, that does not project above the level of the upper surface of the asbestos board.

Thermometer. 3. The thermometer shall conform to the following specifications:

Type: Etched stem glass.
Total length: 305 mm.
Stem: Plain front, enamel back, suitable thermometer tubing. Diameter 6 to 7 mm.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Bulb: Corning Normal, Jena 16 III, or equally suitable thermometric glass.
Length, 13 mm. maximum.
Diameter, not greater than stem.
Actuating liquid: Mercury.
Range: +20° to +760° F.
Immersion: One inch. The words "1-in. Immersion" shall be etched on the stem and also a line around the stem to indicate the depth of immersion.

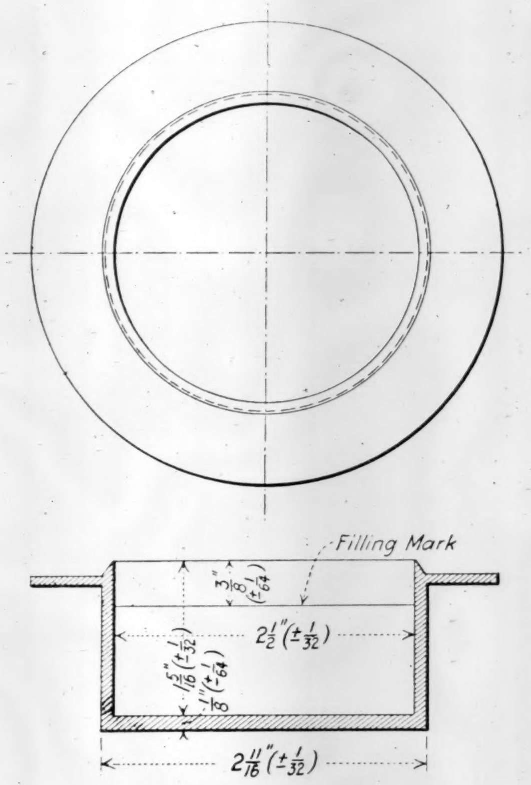

FIG. 1.—Cleveland Open Cup

Distance to 20° line from bottom of bulb: 40 to 50 mm.
Distance to 760° line from top of stem: 30 to 45 mm.
Filled: Nitrogen gas.
Top finish: Red glass ring.
Graduation: All lines, figures and letters clear cut and distinct.
Scale graduated in 5° divisions.
Scale numbered every 20°, the first and each succeeding 10° F. line to be longer than the others.
Special Marking: "A.S.T.M. Open Flash," serial number and manufacturer's name or trade mark etched on stem.

Accuracy: Error at any point on scale shall not exceed one-half smallest scale division up to 700° F.

Test for permanency of range: After being subjected to a temperature of 700° F. for 24 hours the accuracy shall be within the limit specified.

Points to be tested for certification: 32°, 212°, 400°, 700° F.

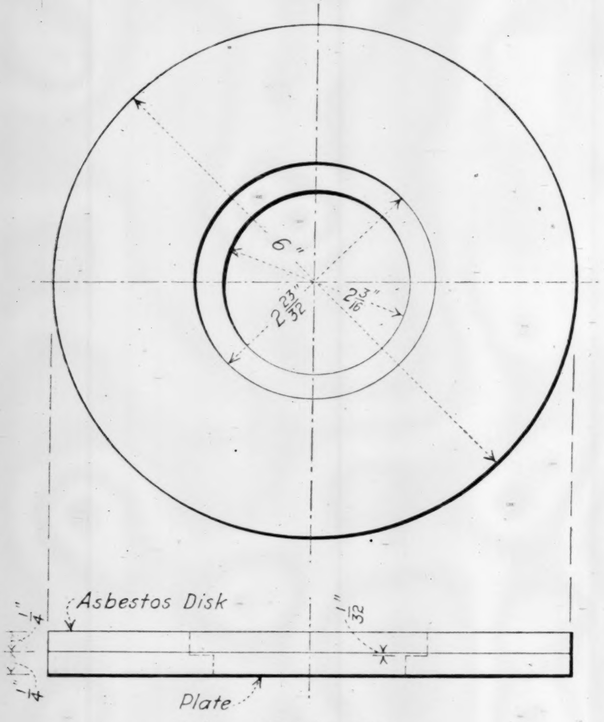

FIG. 2.—Heating Plate

PROCEDURE

Procedure. 4. (*a*) The thermometer shall be suspended or held in a vertical position by any suitable device. The bottom of the bulb shall be $\frac{1}{4}$ in. (0.635 cm.)[1] from the bottom of the cup, and above a point half way between the center and back of the cup.

(*b*) The cup shall be filled with the oil to be tested in such a manner that the top of the meniscus is exactly at the filling line at room temperature. The surface of the oil shall be free from bubbles. There shall be no oil above the filling line or on the outside of the apparatus.

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[1] The immersion line engraved on the thermometer stem will be $\frac{1}{16}$ in. (0.159 cm.) below the level of the rim of the cup.

(*c*) The test flame shall be approximately $\frac{5}{32}$ in. (0.397 cm.) in diameter.

NOTE.—For purposes of comparison it is recommended that a bead of suitable light colored material be mounted in a convenient position so that the size of the test flame can be determined. The device for applying the flame may be of any suitable type but it is suggested that the tip be approximately $\frac{1}{16}$ in. (0.159 cm.) in diameter at the end and that the orifice be $\frac{1}{32}$ in. (0.079 cm.) in diameter. If the device for operating the test flame be mounted in such a manner as to permit automatic duplication of the sweep of the test flame the radius of swing shall be not less than 6 in.

(*d*) The test flame shall be applied as the temperature read on the thermometer reaches each successive 5° F. mark. The flame shall pass in a straight line (or on the circumference of a circle having a radius of at least 6 in.) across the center of the cup and at right angles to the diameter passing through the thermometer. The test flame shall, while passing across the surface of the oil, be in the plane of the upper edge of the cup. The time for the passage of the test flame across the cup shall be approximately one second.

(*e*) The oil shall be heated at a rate not exceeding 30° F. per minute temperature rise, till a point is reached approximately 100° F. below the probable flash point of the oil. Thereafter the rate of heating shall be decreased and for at least the last 50° F. before the flash point is reached, the rate shall be not less than 9 nor more than 11° F. per minute.

Flash Point

5. The flash point shall be taken as the temperature read on the thermometer when a flash appears at any point on the surface of the oil. The true flash must not be confused with a bluish halo that sometimes surrounds the test flame.

Fire Point.

6. After determining the flash point, the heating shall be continued at the specified rate of 9 to 11° F. per minute, and application of the test flame shall be made at the specified intervals until the oil ignites and continues to burn for a period of at least 5 seconds. The method of application of the flame shall be the same or for flash point. The temperature read at the time of the flame application which causes burning for a period of 5 seconds or more shall be recorded as the fire point.

Precautions.

7. The flash point and fire point tests shall be made in a room or compartment free from air drafts. The operator shall avoid breathing over the surface of the oil. It is desirable that the room or compartment be darkened sufficiently so that the flash may be readily discernible.

TENTATIVE METHOD OF TEST
FOR
WATER IN PETROLEUM PRODUCTS AND OTHER BITUMINOUS MATERIALS[1]

Serial Designation: D 95 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Scope. 1. This method of test determines water existing in a sample of bituminous material by distilling the sample with a volatile solvent. This method is suitable for a variety of materials but is especially applicable to petroleum, fuel oil, road oil, coal tar, water-gas tar, coke-oven tar and other petroleum products or bituminous materials.

I. APPARATUS

General. 2. The apparatus shall consist of a metal still or glass flask, heated by suitable means and provided with a reflux condenser discharging into a trap connected to the still or flask. The trap serves to collect and measure the condensed water and to return the solvent to the still.

The type of distilling apparatus used is not an essential feature of this method, but glass has been generally used for petroleum products and the metal still for road materials and tars.

Metal Still. 3. (*a*) The metal still (Fig. 1(*a*)) shall be a vertical cylindrical vessel, preferably of copper, having a faced flange at the top to which the head is tightly attached by means of a clamp. The head shall be of metal, preferably of brass or copper, and be provided with a tubulation 1 in. in inside diameter.

Glass Still. (*b*) The glass flask (Fig. 1(*b*)) shall be of the short neck, round-bottom type, made of well-annealed glass, having an approximate capacity of 500 cc.

Heat Source. 4. The burner used with the metal still shall be a ring gas burner 4 in. (100 mm.) in inside diameter. With the glass flask, an ordinary gas burner or electric heater may be used as the source of heat.

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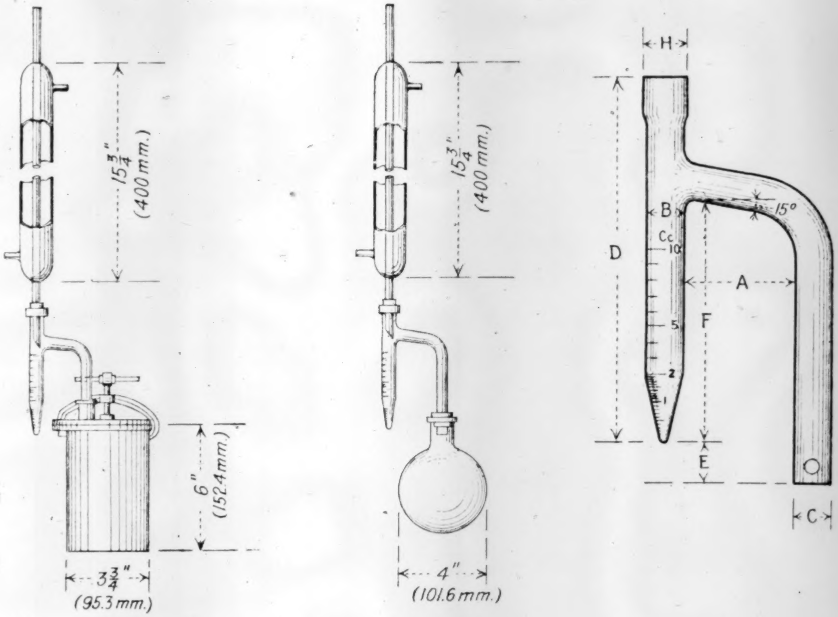
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. H. Fulweiler, Chairman of Sub-Committee, of Committee E-1, on Water in Bituminous Materials, 319 Arch St., Philadelphia, Pa.

Condenser. 5 The condenser shall be of the water-cooled, reflux, glass-tube type, having a condenser jacket not less than 400 mm. ($15\frac{3}{4}$ in.) in length with an inner tube 12 to 16 mm. ($\frac{1}{2}$ to $\frac{5}{8}$ in.) in diameter. The end of the condenser to be inserted in the trap shall be ground off at an angle of 60 deg.



A- ------------------ 45 to 55 mm. = $1\frac{3}{4}$" to $2\frac{1}{8}$"
B-(Inside Diameter) 14 „ 16 mm. = $\frac{9}{16}$" „ $\frac{5}{8}$"
C-(Inside Diameter) 12 „ 16 mm. = $\frac{1}{2}$" „ $\frac{5}{8}$"
D- ------------------ 150 „ 170 mm. = 6" „ $6\frac{3}{4}$"
E- ------------------ 25 „ 38 mm. = 1" „ $1\frac{1}{2}$"
F- ------------------ 100 „ 108 mm. = 4" „ $4\frac{1}{4}$"
H- ------------------ 18 „ 19 mm. = $\frac{11}{16}$" „ $\frac{3}{4}$"

(*a*) (*b*) (*c*)

FIG. 1.

Trap. 6. The trap shall be made of well-annealed glass constructed in accordance with Fig. 1 (*c*) and shall be graduated as shown from 0 to 10 cc. in 0.1 cc. divisions. The error of any indicated capacity shall not be greater than 0.05 cc.

The outside diameters should be preferably 2.5 to 3.5 mm. ($\frac{3}{32}$ to $\frac{1}{8}$ in.) greater than the inside diameters specified.

Solvent. 7. (*a*) The solvent used when testing petroleum products or bituminous materials derived from petroleum shall be gasoline free from water and shall conform to the following distillation requirements, determined in accordance with the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 - 23 T) of the American Society for Testing Materials:[1]

5 per cent shall distill at a temperature not below 194° F. (90° C.) nor above 212° F. (100° C.)
90 per cent shall distill below 410° F. (210° C.)

(*b*) The solvent used when testing bituminous materials derived from coal tar, water-gas tar, etc., shall be a coal-tar naphtha or a light oil and shall conform to the following distillation requirements, determined in accordance with the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 - 23 T) of the American Society for Testing Materials:[1]

98 per cent shall distill between 248° F. (120° C.) and 482° F. (250° C.)

II. SAMPLE

Sample. 8. The sample shall be thoroughly representative of the material to be tested and the portion of the sample used for the test shall be thoroughly representative of the sample itself. Deviation from this requirement shall not be permitted.

NOTE.—The difficulties in obtaining proper representative samples for this determination are unusually great so that the importance of sampling cannot be too strongly emphasized.

III. PROCEDURE

Procedure. 9. When the sample to be tested contains less than 10 per cent of water, exactly 100 cc. of the material to be tested shall be placed into the still or flask and thoroughly mixed with an equal volume of solvent by swirling, proper care being taken to avoid any loss of material. If the material is measured by volume, an accurate 100-cc. graduated cylinder shall be used and the contents transferred to the still by rinsing with one 50-cc. portion of solvent followed by two successive 25-cc. portions of solvent, the cylinder being allowed to drain each time. When the sample to be tested contains more than 10 per cent of water, the volume of material used shall be decreased to that which will yield somewhat less than 10 cc. of water.

NOTE.—In special cases where the water content exceeds 10 per cent and it is not desirable to reduce the size of the sample to that which will yield somewhat less than 10 cc. of water, a distilling tube receiver graduated from 0 to 25 cc. may be used. This tube shall be graduated from 0 to 2 cc. in 0.1 cc., from 2 to 5 cc. in 0.2 cc. and from 5 to 25 cc. in 0.5 cc.

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[1] See p. 665.

The connections between the still or flask, trap and condenser shall be made by means of tight-fitting corks as shown in Figs. 1 (*a*) and (*b*) When the metal still is used, a heavy paper gasket moistened with the solvent shall be inserted between the lid and flange before attaching the clamp.

Heat shall then be applied and so regulated that the condensed distillate falls from the end of the condenser at the rate of from 2 to 5 drops per second. The ring burner used with the metal still should be placed about 3 in. above the bottom of the still at the beginning of the distillation and gradually lowered as the distillation proceeds.

The distillation shall be continued at the specified rate until no water is visible on any part of the apparatus except at the bottom of the trap. This operation usually requires less than an hour. A persistent ring of condensed water in the condenser tube shall be removed by increasing the rate of distillation for a few minutes.

Calculation of Results.

10. The volume of condensed water measured in the trap at room temperature multiplied by 100 and divided by the volume of the sample used shall be the percentage of water and shall be reported as "............ per cent water by volume, A.S.T.M. method."

IV. ACCURACY

Accuracy.

11. The accuracy to be expected with this method is that duplicate determinations of water should not differ from each other by more than one division on the trap.

TENTATIVE METHOD OF TEST
FOR
CLOUD AND POUR POINTS OF PETROLEUM PRODUCTS[1]

Serial Designation: D 97 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922, 1923

Cloud Point. 1. (*a*) The Cloud Point of a petroleum oil is that temperature at which paraffin wax or other solid substances begin to crystallize out or separate from solution when the oil is chilled under certain definite specified conditions.

Pour Point. (*b*) The Pour Point of a petroleum oil is the lowest temperature at which this oil will pour or flow when it is chilled without disturbance under certain definite specified conditions.

Scope. 2. (*a*) The test for cloud point shall be used only for oils which are transparent in layers 1½ in. thick.

(*b*) The test for pour point shall be used for all other petroleum oils and may be used for oils on which the test for cloud point is permitted.

I. APPARATUS

(See Fig. 1)

Test Jar. 3. The test jar, *a*, shall be of clear glass, cylindrical form, flat bottom, approximately 1¼ in. in inside diameter and 4½ to 5 in. high. An ordinary 4-oz. oil sample bottle may be used if the test jar is not available.

Thermometer. 4. The thermometer, *b*, shall conform to the following specifications.

Type: Etched stem glass.
Total length: 222 mm.
Stem: Plain front, enamel back, suitable thermometer tubing; diameter 7 to 8 mm.
Bulb: Corning Normal. Jena 16 III, or equally suitable thermometric glass; maximum length, 9.5 mm.; diameter, not greater than stem.
Actuating liquid: Mercury.
Range: −36° to +120° F.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

Immersion: 4¼ in. The words "4¼-in. immersion" etched on the stem and also a line around the stem to indicate the depth of immersion.
Distance to –36° line from bottom of bulb: 120 to 130 mm.
Distance to 120° line from top of stem: 19 to 25 mm.
Expansion chamber: To hold 212° F.
Filled: Nitrogen gas.
Top finish: Plain.
Graduation: All lines, figures and letters clear cut and distinct.
Scale graduated in 2° F. divisions.
Scale numbered every 20° F. starting at –20° F., the –30° line and each succeeding 10° line to be longer than the others.
Special markings: "A.S.T.M. Cloud and Pour," serial number and manufacturer's name or trade mark etched on the stem.
Accuracy: Error at any point on scale shall not exceed one smallest scale division.
Points to be tested for certification: –28°, +32°, +92° F.

Cork. 5. The cork, *c*, shall fit the test jar, and shall be bored centrally to take the test thermometer.

Jacket. 6. The jacket, *d*, shall be of glass or metal, shall be water tight, of cylindrical form, flat bottom, about 4½ in. deep, with inside diameter ½ in. greater than outside diameter of the test jar.

Cork Disk. 7. A disk of cork or felt, *e*, ¼ in. thick and of the same diameter as the inside of the jacket will be required.

Gasket. 8. The ring gasket, *f*, shall be about $\frac{3}{16}$ in. thick, and made to fit snugly around the outside of the test jar and loosely inside the jacket. This gasket may be made of cork, felt or other suitable material, elastic enough to cling to the test jar and hard enough to hold its shape. The purpose of the ring gasket is to prevent the test jar from touching the jacket.

Bath. 9. The cooling bath, *g*, shall be of a type suitable for obtaining the required temperatures. The size and shape of the bath are optional but a support, suitable for holding the jacket firmly in a vertical position, is essential. The required bath temperatures may be maintained by refrigeration if available, otherwise by suitable freezing mixtures.

NOTE.—The freezing mixtures commonly used are as follows:

For temperatures down to 35° F., ice and water.
" " " " –5° F., crushed ice and sodium chloride.
" " " " –25° F., crushed ice and calcium chloride.
" " " " –70° F., solid carbon dioxide and acetone.

The last named mixture may be made as follows: In a covered metal beaker chill a suitable amount of acetone to 10° F., or lower, by means of an ice-salt mixture. Invert a cylinder of liquid carbon dioxide and draw off carefully into a chamois skin bag the desired amount of carbon dioxide, which through rapid evaporation will quickly become solid. Then add to the chilled acetone enough of the solid carbon dioxide to give the desired temperature.

II. PROCEDURE

Procedure for Cloud Point.

10. The oil to be tested shall be brought to a temperature at least 25° F. above the approximate cloud point. Moisture, if present, shall be removed by any suitable method, as by filtration through dry filter paper until the oil is perfectly clear, but such filtration shall be made at a temperature at least 25° F. above the approximate cloud point.

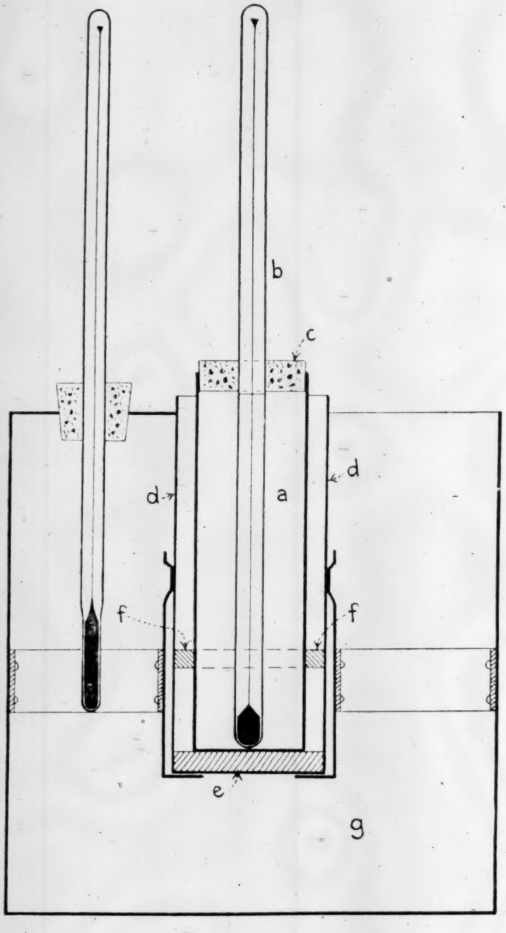

FIG. 1.—Apparatus for Cloud and Pour Test (as assembled for Cloud Test)

The clear oil shall be poured into the test jar, *a*, to a height of not less than 1 nor more than 1¼ in. The test jar may be marked to indicate the proper level.

The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb resting on the bottom of the jar.

The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar with the ring gasket, *f*, 1 in. above the bottom shall be inserted into the jacket. The disk, jacket and inside of jacket shall be clean and dry.

The temperature of the cooling bath, *g*, shall be adjusted so that it is below the cloud point of the oil by not less than 15 nor more than 30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

At each test thermometer reading which is a multiple of 2° F., the test jar shall be removed from the jacket, quickly but without disturbing the oil, inspected for cloud, and replaced in the jacket. This complete operation shall require not more than three seconds.

When such inspection first reveals a distinct cloudiness or haze in the oil at the bottom of the test jar, the reading of the test thermometer, corrected for error if necessary, shall be recorded as the cloud point.

11. The oil to be tested shall be brought to a temperature of 90° F., or to a temperature 15° F. higher than its pour point if this pour point is above 75° F. The oil shall then be poured into the test jar, *a*, to a height of not less than 2 nor more than 2¼ in.[1] The jar may be marked to indicate the proper level.

The test jar shall be tightly closed by the cork, *c*, carrying the test thermometer, *b*, in a vertical position in the center of the jar with the thermometer bulb immersed so that the beginning of the capillary shall be ⅛ in. below the surface of the oil.

The disk, *e*, shall be placed in the bottom of the jacket, *d*, and the test jar, with the ring gasket, *f*, 1 in. above the bottom, shall be inserted into the jacket. The disk, gasket and inside of jacket shall be clean and dry.

After the oil has cooled enough to allow the formation of paraffin wax crystals, great care shall be taken not to disturb the mass of the oil nor to permit the thermometer to shift in the oil. Any disturbance of the spongy network of wax crystals will lead to low and fictitious results.

The temperature of the cooling bath, *g*, shall be adjusted so that it is below the pour point of the oil by not less than 15 nor more than

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[1] Test jar and contents shall be immediately placed in the previously assembled apparatus.

30° F. and this temperature shall be maintained throughout the test. The jacket, containing the test jar, shall be supported firmly in a vertical position in the cooling bath so that not more than 1 in. of the jacket projects out of the cooling medium.

At each test thermometer reading which is a multiple of 5° F., the test jar shall be removed from the jacket carefully and shall be tilted just sufficiently to ascertain whether there is a movement of the oil in the test jar. The complete operation of removal and replacement shall require not more than three seconds. As soon as the oil in the test jar does not flow when the jar is tilted, the test jar shall be held in a horizontal position for exactly five seconds, as noted by a stop watch or other accurate timing device and observed carefully. If the oil shows any movement under these conditions, the test jar shall be immediately replaced in the jacket and the same procedure repeated at the next temperature reading 5° F. lower.

The test shall be continued in this manner until a point is reached at which the oil in the test jar shows no movement when the test jar is held in a horizontal position for exactly five seconds. The reading of the test thermometer at this temperature, corrected for error if necessary, shall be recorded. The pour point shall be taken as the temperature 5° F. above this solid point.

TENTATIVE METHODS OF TESTING GAS OILS

(GRAVITY, DISTILLATION, SULFUR, CARBON RESIDUE, POUR POINT, VISCOSITY, WATER)[1]

Serial Designation: D 158 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

GRAVITY

Gravity.

1. The gravity shall be determined at 60°/60° F. (15.6°/15.6° C.) in a pyknometer, accurately standardized, or by means of a hydrometer or Westphal balance, the accuracy of which has been verified. The gravity shall be recorded as specific gravity or gravity, degrees A.P.I., at 60°/60° F. (15.6°/15.6° C.).

DISTILLATION

Apparatus

Flask.

2. *Flask.*—The distillation flask shall be a Saybolt distilling flask, the dimensions and permissible variations being as follows:

	Centimeters	Inches	Tolerances, Cm.
Diameter of bulb, outside	8.57	3.37	0.3
Diameter of neck, inside	1.50	0.59	0.1
Over all length, neck plus bulb	21.50	8.46	0.3
Length of vapor tube	17.50	6.89	0.5
Diameter of vapor tube, outside	0.60	0.24	0.05
Diameter of vapor tube, inside	0.40	0.16	0.05
Thickness of vapor tube wall	0.10	0.04	0.02

The center of the vapor tube shall be 6.5 cm. (2.56 in.), ±0.3 cm., below the top of the neck. The tube is approximately in the middle of the neck and set at an angle of 75 deg., ±3 deg., with the vertical.

Condenser.

3. *Condenser.*—The condenser[2] shall consist of a $\frac{9}{16}$-in. (14.29-mm.), outside diameter, No. 20 Stubbs Gage seamless brass tube, 22

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

[2] A condenser conforming to these specifications is illustrated in the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 - 23 T) of the American Society for Testing Materials. See p. 665.

in. (55.88 cm.) in length. It shall be set at an angle of 75 deg. with the vertical and shall be surrounded with a bath 15 in. (38.1 cm.) in length, approximately 4 in. (10.16 cm.) in width by 6 in. (15.24 cm.) in height. The bath shall be provided with suitable connections for circulating water through it. The lower end of the condenser tube shall be cut off at an acute angle, and curved downward for a length of 3 in. (7.62 cm.) and slightly backward so as to insure contact with the wall of the receiving graduate at a point approximately 1 to $1\frac{1}{4}$ in. (2.54 to 3.18 cm.) below the top of the graduate when it is in position to receive the distillate.

Shield. 4. *Shield.*—The shield[1] shall be made of approximately No. 22 gage sheet metal and shall be 19 in. (48.26 cm.) in height, 11 in. (27.94 cm.) in length and 8 in. (20.32 cm.) in width, with a door on one narrow side, with two openings, 1 in. (2.54 cm.) in diameter, equally spaced, in each of the two narrow sides, and with a slot cut in one side for the vapor tube. The centers of these four openings shall be $8\frac{1}{2}$ in. (21.59 cm.) below the top of the shield. There shall also be three $\frac{1}{2}$-in. (1.27-cm.) holes in each of the four sides with their centers 1 in. (2.54 cm.) above the base of the shield.

Support. 5. *Ring Support and Hard Asbestos Boards.*—The ring support may be of the ordinary laboratory type, 4 in. (10.16 cm.) or larger in diameter, and shall be supported on a stand inside the shield. There shall be two hard asbestos boards: One 6 by 6 by $\frac{1}{4}$ in. (15.24 by 15.24 cm. by 6.35 mm.) with a hole $2\frac{3}{4}$ in. (6.99 cm.) in diameter in its center, the sides of which shall be perpendicular to the surface; the other, an asbestos board to fit tightly inside the shield, with an opening 4 in. (10.16 cm.) in diameter concentric with the ring support. These shall be arranged as follows: The second asbestos board shall be placed on the ring and the first or smaller asbestos board on top so that it may be moved in accordance with the directions for placing the distilling flask. Direct heat shall be applied to the flask only through the $2\frac{3}{4}$-in. (6.99-cm.) opening in the first asbestos board.

Heater. 6. *Gas Burner.*—The burner shall be so constructed that sufficient heat can be obtained to distill the product at the uniform rate specified below. The flame should never be so large that it spreads over a circle of diameter greater than $4\frac{1}{2}$ in. (11.43 cm.) on the under surface of the asbestos board. A sensitive regulating valve and gas pressure governor are desirable adjuncts, as they give complete control of heating.

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[1] A shield conforming to these specifications is illustrated in the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 – 23 T) of the American Society for Testing Materials. See p. 665.

7. *Thermometer.*—The A.S.T.M. High Distillation Thermometer, conforming to the requirements specified in Section 6 (*b*) of the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosene, and Similar Petroleum Products (Serial Designation: D 86 – 23 T) of the American Society for Testing Materials,[1] shall be used. **Thermometer.**

8. *Graduates.*— **Graduates.**

(*a*) *For Sample.*—A graduate or pipette graduated to deliver 200 cc., ± 1.0 cc., may be used for measuring the sample to be tested.

(*b*) *For Fractions.*—The graduates used for measuring fractions shall be of the cylindrical type, of uniform diameter, with a pressed or molded base and a lipped top. The cylinder shall be graduated to contain 100 cc. and the graduated portion shall be not less than 7 in. (17.78 cm.) nor more than 8 in. (20.32 cm.) in length. It shall be graduated in single cubic centimeters and each fifth mark shall be distinguished by a longer line. It shall be numbered from the bottom at intervals of 10 cc. The distance from the 100-cc. mark to the rim shall be not less than $1\frac{1}{4}$ in. (3.18 cm.) nor more than $1\frac{3}{4}$ in. (4.45 cm.). The graduations shall not be in error by more than 1 cc. at any point on the scale.

PROCEDURE

9. (*a*) Provision shall be made for circulating water through the condenser. **Procedure.**

(*b*) The condenser tube shall be swabbed to remove any liquid remaining from the previous test. A piece of soft, lint-free cloth attached to a cord or copper wire may be used for this purpose.

(*c*) A volume of water-free oil equivalent to 200 cc. at 55 to 65° F. (12.8 to 18.3° C.) shall be placed in the flask.

NOTE.—The method of dehydrating the oil is optional. In the case of non-viscous oils gravity settling or centrifuging often produce the desired result. More viscous oils can be dehydrated by: (1) Heating with a suitable dehydrating agent in an autoclave up to a temperature not exceeding 392° F. (200° C.). This method is described in detail in U. S. Bureau of Mines *Bulletin No. 207* on the Analytical Distillation of Petroleum and Its Products. (2) Preliminary Distillation. The general procedure is to heat very slowly a mass of oil in a distillation flask fitted with a thermometer and connected to a water-cooled condenser and to play a flame on the neck of the flask in such a manner that it is heated uniformly to a temperature slightly in excess of 212° F. (100° C.). When the water is completely distilled, heating is discontinued and the flask allowed to cool; the thermometer is removed and the distillate, which has been separated from the water, is poured back. The mass of oil is then thoroughly mixed and the test sample withdrawn.

The method of measuring is optional, depending on the viscosity of the product to be tested. The following schemes have been used with satisfactory results:

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[1] See p. 665.

For non-viscous or moderately viscous oils, measure at room temperature from a graduate or pipette calibrated to deliver 200 cc.

Oils of moderate or high viscosity can be handled in a pipette if suitable precautions are taken. The pipette should not be drawn to a point and the oil may be drawn in by mechanical suction and expelled under air pressure. Drainage can be completed by warming the pipette gently with a luminous gas flame, if care is taken not to ignite the charge of oil nor to boil or carbonize the oil residue in the pipette.

Oils of moderate or high viscosity can often be handled most conveniently by weighing into the tared flask the equivalent of 200 cc. at 60° F. The weight to be used is 200 times the specific gravity of the oil at 60° F.

(*d*) The thermometer, provided with a cork, shall be fitted tightly into the flask so that it will be in the middle of the neck and so that the lower end of the capillary tube is on a level with the inside of the bottom of the vapor outlet tube at its junction with the neck of the flask.

(*e*) The charged flask shall be placed over the $2\frac{3}{4}$-in. (6.99-cm.) opening in the asbestos board with the vapor outlet tube inserted into the condenser tube. A tight connection may be made by means of a cork through which the vapor tube passes. The position of the flask shall be so adjusted that the vapor tube extends into the condenser tube not less than 1 in. (2.54 cm.) nor more than 2 in. (5.08 cm.).

(*f*) A clean, dry graduated cylinder shall be placed at the outlet of the condenser tube in such position that the condenser tube shall extend into the graduate approximately 1 in. (2.54 cm.) but not below the 100-cc. mark.

Distillation. 10. When everything is in readiness, water shall be circulated through the condenser bath at such a rate that the water overflowing the condenser shall be at a temperature of 90 to 100° F. (32.2 to 37.8° C.). Heat shall be applied to the contents of the flask at a uniform rate, so regulated that the first drop of condensate falls from the condenser in not less than 10 nor more than 15 minutes. When the first drop falls from the end of the condenser, the reading of the distillation thermometer shall be recorded as the *initial boiling point*. The receiving cylinder shall then be moved so that the end of the condenser tube shall touch the side of the cylinder. The heat shall then be so regulated that the distillation will proceed at a uniform rate of not less than 8 cc. nor more than 10 cc. per minute. A fraction shall be separated at every temperature point above the initial boiling point that is a multiple of 50° F. When the temperature of the distilling vapors reaches 500° F. (260° C.), the temperature of the water in the condenser bath shall be adjusted to approximately 140° F. and the bath maintained between 140 and 160° F. (60 to 71.1° C.) for the remainder of the test. The distillation shall be continued until a vapor temperature of 700° F. (371.1° C.) is reached or until the maximum temperature point is reached. Sufficient time shall be allowed after distillation is discontinued for the condenser to drain into the final fraction.

The maximum temperature point may result from complete distillation of the oil below 700° F. (371.1° C.), or from cracking.

In case the oil distills completely below 700° F. (371.1° C.), the final adjustment of heat shall be made when a quantity of distillate amounting to 90 per cent of the sample has been collected. The heating shall be continued until the mercury reaches a maximum height and starts to fall consistently; but in no case should the period between the 90-per-cent point and the maximum temperature be more than 10 minutes. The highest temperature observed on the distillation thermometer shall be recorded as the *maximum temperature.*

Cracking will be evidenced by an increase in distilling rate with a thermometer reading that may advance very slowly, remain stationary, or recede, and an effort to adjust the distilling rate will usually result in a decided drop in the temperature reading. When this condition is observed, distillation shall be discontinued and the preceding fraction considered as the final fraction.

Each fraction shall be brought to room temperature, the volume read and recorded, and the fraction set aside for the determination of the gravity. The percentage of distillate in each fraction shall be calculated and recorded. The difference between 100 and the sum of the distillates in per cent shall be calculated and recorded as *residue and loss.*

The gravity of each fraction and of the residue shall be determined at or corrected to 60° F. (15.6° C.). The gravity of each fraction shall be recorded as specific gravity or as gravity, degrees A. P. I.

SULFUR

Sulfur.

11. The sulfur shall be determined in accordance with the Tentative Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (Serial Designation: D 129 - 22 T) of the American Society for Testing Materials.[1]

CARBON RESIDUE

Carbon Residue.

12. The carbon residue shall be determined in accordance with the Conradson Method, as described in Sections 3 and 4 of the Standard Methods of Testing Lubricants (Specific Gravity, Free Acid, Car-

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 22, Part I, p. 777 (1922).

bon Residue, Viscosity) (Serial Designation: D 47) of the American Society for Testing Materials.[1]

POUR POINT

Pour Point. 13. The pour point shall be determined in accordance with the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (Serial Designation: D 97 – 23 T) of the American Society for Testing Materials.[2]

VISCOSITY

Viscosity. 14. (*a*) The viscosity of oils showing a time of less than 500 seconds, Saybolt Universal, at 100° F. (37.8° C.), shall be determined on the Saybolt Universal Viscosimeter at 100° F. in accordance with the method described in the Tentative Methods of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88 – 23 T) of the American Society for Testing Materials.[3]

(*b*) The viscosity of oils showing a time of over 500 seconds, Saybolt Universal, at 100° F., shall be determined on the Saybolt Furol Viscosimeter at 122° F. (50° C.) in accordance with the Tentative Methods of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88 – 23 T) of the American Society for Testing Materials,[3] except that oils showing a time of less than 25 seconds, Saybolt Furol, at 122° F. (50° C.) shall be tested on the Saybolt Universal at 122° F. (50° C.).

WATER

Water. 15. Water shall be determined in accordance with the Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T) of the American Society for Testing Materials.[4]

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 698.

[3] See p. 672.

[4] See p. 694.

TENTATIVE SPECIFICATIONS
FOR
COMMERCIAL SIZES OF BROKEN STONE AND BROKEN SLAG FOR HIGHWAY CONSTRUCTION.[1]

Serial Designation: D 63 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1920; REVISED, 1923.

Material Covered.

1. These specifications cover the standard size designations and maximum permissible range in mechanical analyses for nine commercial grades of broken stone and broken slag, when used in the construction of plain or bituminous macadam, bituminous concrete, sheet asphalt and cement-concrete roads and pavements.

I. MANUFACTURE.

Screening Process.

2. The standard sizes herein specified may be produced from the run of the crusher by means of any screening process in which the factors influencing the efficiency of the screening operation are so adjusted that the designated sizes will conform to the requirements for mechanical analysis specified in Section 4.

II. STANDARD SIZES.

Standard Sizes.

3. Each of the standard sizes shall be designated by reference to both the upper and lower nominal limiting size of the product: thus, "$\frac{1}{4}$ to $\frac{3}{4}$-in. size" indicating that portion of the product of a crusher, all of which is nominally between $\frac{1}{4}$ and $\frac{3}{4}$ in. in size.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

III. PERMISSIBLE VARIATIONS IN MECHANICAL ANALYSIS.

Permissible Variations in Mechanical Analysis.

4. The designated size for each grade together with the corresponding maximum permissible variations in mechanical analyses as determined by the use of laboratory screens, are given in the following table:

MAXIMUM PERMISSIBLE RANGE IN MECHANICAL ANALYSIS FOR EACH SIZE

PERCENTAGE BY WEIGHT PASSING LABORATORY SCREENS.

Designated Size, in.	Diameter of Screen Openings, in.						
	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$2\frac{1}{2}$	$3\frac{1}{2}$
0 - $\frac{1}{4}$	85-100	......	......	......	......	......	......
0 - $\frac{1}{2}$	0- 75	95-100	......	......	......	......	......
0 - $\frac{3}{4}$	40- 80	......	95-100	......	......	......	......
$\frac{1}{4}$ - $\frac{3}{4}$	0- 15	25- 75	95-100	......	......	......	......
$\frac{1}{4}$ - $1\frac{1}{4}$	0- 5	......	25- 75	......	95-100	......	......
$\frac{1}{4}$ - $2\frac{1}{2}$	0- 5	......	......	......	25- 75	95-100	......
$\frac{3}{4}$ - $1\frac{1}{4}$	......	......	0- 15	25- 75	95-100	......	......
$1\frac{1}{4}$ - $2\frac{1}{2}$	......	......	......	......	0- 15	95-100	......
$2\frac{1}{2}$ - $3\frac{1}{2}$[a]	......	......	......	......	......	0- 15	95-100

[a] In the case of light or porous slags a 4-in. maximum size may be specified instead of 3½ in.

IV. SIZE OF SAMPLES.

Samples.

5. Samples of broken stone or broken slag which are to be examined to determine conformity with these specifications shall weigh at least 50 times the weight of the largest piece therein and be strictly representative of the product sampled.

EXPLANATORY STATEMENT.

The commercial sizes designated in the accompanying proposed specifications provide primarily for the separation of the run of crusher into five sizes not including the 0 to $\frac{1}{2}$-in. size. Although the limiting sizes were determined after carefully considering the size requirements of the various types of roads using broken stone or slag, no definite requirements regarding use have been inserted, as such requirements will be included in specifications which are to be prepared by Committee D-4. It will be noted that a general tolerance of 15 per cent on the lower limiting size and 5 per cent on the upper limiting size for each grade is specified. It is felt that this will cover all unavoidable variations in grading of a given designated product. An intermediate size requirement of from 25 to 75 per cent is also given for the $\frac{1}{4}$ to $\frac{3}{4}$-in. and the $\frac{3}{4}$ to $1\frac{1}{4}$-in. sizes. It is felt that for the two larger sizes an intermediate size requirement is not necessary. For the combination sizes which will ordinarily be used in cement-concrete work, a lower tolerance of 5 per cent is specified. In Table I various uses to which the different grades are adapted are indicated.

TABLE I.—VARIOUS USES FOR WHICH THE DIFFERENT GRADES OF STONE ARE ADAPTED.

Designated Size, in.	Suggested Uses.
0 - $\frac{1}{4}$.....	For fine screenings for waterbound macadam.
0 - $\frac{1}{2}$.....	" fine aggregate for bituminous concrete.
$\frac{1}{4}$ - $\frac{3}{4}$.....	" dustless screenings or chips for bituminous macadam or bituminous surface treatment.
$\frac{3}{4}$ - $1\frac{1}{4}$.....	" coarse chips or 1-in. stone for bituminous macadam.
$1\frac{1}{4}$ - $2\frac{1}{2}$.....	" wearing course, waterbound macadam or bituminous macadam.
$2\frac{1}{2}$ - $3\frac{1}{2}$.....	" broken-stone base course.
	COMBINATION SIZES.
0 - $\frac{3}{4}$.....	For coarse screenings for waterbound macadam.
$\frac{1}{4}$ - $1\frac{1}{4}$.....	" aggregate for reinforced concrete, bituminous concrete, sheet asphalt binder course.
$\frac{1}{4}$ - $2\frac{1}{2}$.....	" coarse aggregate for cement-concrete roads and structures.

TENTATIVE SPECIFICATIONS
FOR
BROKEN SLAG FOR BITUMINOUS MACADAM WEARING COURSE[1]

Serial Designation: D 159 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Material Covered. 1. These specifications cover $\frac{3}{4}$ to $\frac{1}{4}$-in., $1\frac{1}{4}$ to $\frac{3}{4}$-in., and $2\frac{1}{2}$ to $1\frac{1}{4}$-in. or $3\frac{1}{2}$ to $2\frac{1}{2}$-in. size slag to be used in the construction of a bituminous macadam wearing course in which the bituminous material is applied by the penetration method. The maximum size of $3\frac{1}{2}$ in. specified for the wearing course is on the basis of a course $2\frac{1}{2}$ to $3\frac{1}{2}$ in. in thickness after consolidation. The $1\frac{1}{4}$ to $\frac{3}{4}$-in. size should be used to fill the surface voids after the first application of bituminous material, and the $\frac{3}{4}$ to $\frac{1}{4}$-in. size after the application of the seal coat.

General Characteristics of Slag. 2. The broken slag shall be air-cooled blast-furnace slag and shall consist of angular fragments reasonably uniform in density and quality, and reasonably free from thin, elongated or glassy pieces, dirt or other objectionable matter.

Weight. 3. The weight per cubic foot of each size specified shall be not less than 70 lb.

Percentage of Wear. 4. The percentage of wear shall be not more than 12.0 per cent.

3/4 to 1/4-in. Size. 5. The $\frac{3}{4}$ to $\frac{1}{4}$-in. size is that portion of the product of the crusher, which, when tested by means of laboratory screens, shall meet the following requirements:

Passing $\frac{3}{4}$-in. screen	not less than 95 per cent
Passing $\frac{1}{2}$-in. screen	25 to 75 "
Passing $\frac{1}{4}$-in. screen	not more than 15 "

1 1/4 to 3/4-in. Size. 6. The $1\frac{1}{4}$ to $\frac{3}{4}$-in. size is that portion of the product of the crusher, which, when tested by means of laboratory screens, shall meet the following requirements.

Passing $1\frac{1}{4}$-in. screen	not less than 95 per cent
Passing 1-in. screen	25 to 75 "
Passing $\frac{3}{4}$-in. screen	not more than 15 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

2½ to 1¾-in. Size.

7. The 2½ to 1¼-in. and 3½ to 2½-in. sizes are that portion of the product of the crusher, which, when tested by means of laboratory screens, shall conform to one of the following requirements:

Passing 2½-in. screen	not less than 95 per cent
Total passing 1¼-in. screen	not more than 15 "
Passing 3½-in. screen	not less than 95 per cent
Total passing 2½-in. screen	not more than 15 "

NOTE.—One of the above alternate sizes for coarse slag should be specified to best suit the local and service conditions.

Methods of Testing.

8. (*a*) *Weight per Cubic Foot.*—The weight per cubic foot shall be determined in accordance with the Standard Method of Test for Unit Weight of Aggregate for Cement Concrete (Serial Designation: C 29) of the American Society for Testing Materials.[1]

(*b*) *Percentage of Wear.*—The percentage of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Road Materials (Serial Designation: D 2) of the American Society for Testing Materials,[1] using, however, a volume of 4000 cc. measured loose of the broken slag of the size specified in the standard test.

Sampling

9. The method of sampling shall conform to the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (Serial Designation: D 75) of the American Society for Testing Materials.[2]

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[1] 1921 Book of A.S.T.M. Standards.

[2] A.S.T.M. Standards Adopted in 1922.

TENTATIVE SPECIFICATIONS

FOR

BROKEN SLAG FOR BITUMINOUS CONCRETE (COARSE-GRADED AGGREGATE TYPE)[1]

Serial Designation: D 160 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

Material Covered. 1. These specifications cover $\frac{3}{4}$ to $\frac{1}{4}$-in. and $1\frac{1}{4}$ to $\frac{1}{4}$-in. size slag to be used in the construction of a coarse-graded bituminous concrete wearing course constructed by the mixing method. The $\frac{3}{4}$ to $\frac{1}{4}$-in. size should be used after the application of the seal coat when a seal coat is used.

General Characteristics of Slag. 2. The broken slag shall be air-cooled blast-furnace slag and shall consist of angular fragments reasonably uniform in density and quality, and reasonably free from thin, elongated or glassy pieces, dirt or other objectionable matter.

Weight. 3. The weight per cubic foot of each size specified shall be not less than 70 lb.

Percentage of Wear. 4. The percentage of wear shall be not more than 10.0 per cent.

3/4 to 1/4-in. Size. 5. The $\frac{3}{4}$ to $\frac{1}{4}$-in. size is that portion of the product of the crusher, which, when tested by means of laboratory screens, shall meet the following requirements:

Passing $\frac{3}{4}$-in. screen	not less than 95 per cent
Passing $\frac{1}{2}$-in. screen	25 to 75 "
Passing $\frac{1}{4}$-in. screen	not more than 15 "

1 1/4 to 1/4-in. Size. 6. The $1\frac{1}{4}$ to $\frac{1}{4}$-in. size is that portion of the product of the crusher, which, when tested by means of laboratory screens, shall meet the following requirements:

Passing $1\frac{1}{4}$-in. screen	95 to 100 per cent
Passing $\frac{3}{4}$-in. screen	25 to 75 "
Passing $\frac{1}{4}$-in. screen	not more than 5 "

Methods of Testing. 7. (*a*) *Weight per Cubic Foot.*—The weight per cubic foot shall be determined in accordance with the Standard Method of Test for

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

Unit Weight of Aggregate for Cement Concrete (Serial Designation: C 29) of the American Society for Testing Materials.[1]

(*b*) *Percentage of Wear.*—The percentage of wear shall be determined in accordance with the Standard Method of Test for Abrasion of Road Materials (Serial Designation: D 2) of the American Society for Testing Materials,[1] using, however, a volume of 4000 cc. measured loose of the broken slag of the size specified in the standard test.

Sampling.

8. The method of sampling shall conform to the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (Serial Designation: D 75) of the American Society for Testing Materials.[2]

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[1] 1921 Book of A.S.T.M. Standards.

[2] A.S.T.M. Standards Adopted in 1922.

TENTATIVE SPECIFICATIONS
FOR
BROKEN SLAG FOR BITUMINOUS CONCRETE (FINE-GRADED AGGREGATE TYPE)[1]

Serial Designation: D 161 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Material Covered.

1. These specifications cover slag aggregate to be used in the construction of a bituminous concrete wearing surface constructed by the mixing method.

General Characteristics of Slag.

2. The broken slag shall be air-cooled blast-furnace slag and shall consist of angular fragments reasonably uniform in density and quality, and reasonably free from thin, elongated or glassy pieces, dirt or other objectionable matter.

Weight.

3. The weight per cubic foot shall be not less than 70 lb.

Percentage of Wear.

4. The percentage of wear shall be not more than 12.0 per cent.

Slag Aggregate 0 to ½-in. Size.

5. The slag aggregate is that portion of the product of the crusher, which, when tested by means of laboratory screens, shall conform to the following requirements:

Passing ½-in. screen	95 to 100 per cent
Passing ¼-in. screen	0 to 75 "

Methods of Testing.

6. (*a*) *Weight per Cubic Foot.*—The weight per cubic foot shall be determined in accordance with the Standard Method of Test for Unit Weight of Aggregate for Cement Concrete (Serial Designation: C 29) of the American Society for Testing Materials.[2]

(*b*) *Percentage of Wear.*—The percentage of wear shall be determined in accordance with the Standard Test for Abrasion of Road Materials (Serial Designation: D 2) of the American Society for Testing Materials,[2] using, however, a volume of 4000 cc. measured loose of the broken slag of the size specified in the standard test.

Sampling.

7. The method of sampling shall conform to the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (Serial Designation: D 75) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] A.S.T.M. Standards Adopted in 1922.

TENTATIVE SPECIFICATIONS
FOR
SAND FOR SHEET ASPHALT AND BITUMINOUS CONCRETE PAVEMENTS[1]

Serial Designation: D 162 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Material Covered.

1. These specifications cover sand for use in the construction of the surface course of sheet asphalt pavements and those types of bituminous concrete pavements in which sand predominates.

Physical Properties.

2. The grains of the sand shall be clean, tough, rough surfaced and angular. The sand after drying shall be free from lumps or balls of clay or of clay and sand. Before being incorporated into the paving mixture it shall conform to the following requirements as to grading:

Passing 200-mesh sieve	0 to 5 per cent	
Passing 100-mesh sieve, retained on 200-mesh	6 to 25 "	15 to 40 per cent
Passing 80-mesh sieve, retained on 100-mesh	6 to 25 "	
Passing 50-mesh sieve, retained on 80-mesh	5 to 40 "	30 to 60 "
Passing 40-mesh sieve, retained on 50-mesh	5 to 30 "	
Passing 30-mesh sieve, retained on 40-mesh	8 to 25 "	18 to 50 "
Passing 20-mesh sieve, retained on 30-mesh	5 to 15 "	
Passing 10-mesh sieve, retained on 20-mesh	5 to 15 "	
Passing 10-mesh sieve	95 to 100 "	
Passing ¼-in. screen	100 "	

Methods of Testing.

3. *General Characteristics.*—The general characteristics shall be determined by examination under a microscope or a magnifying glass.

4. *Mesh Composition.*—The tests for the mechanical analysis shall be made in accordance with the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material Except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials.[2]

Sampling.

5. The method of sampling shall conform to the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (Serial Designation: D 75) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] A.S.T.M. Standards Adopted in 1922.

TENTATIVE SPECIFICATIONS
FOR
NATURAL OR ARTIFICIAL SAND-CLAY MIXTURES FOR ROAD SURFACING[1]

Serial Designation: D 67 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

General. 1. The sand-clay shall be composed of either a naturally occurring or artificially prepared mixture of hard, durable, preferably angular, fragments of sand together with silt and clay with or without gravel, and shall be free from an excess of feldspar or mica.

Grading. 2. (*a*) When tested by means of laboratory sieves and screens the material shall conform to the following requirements as to grading:

Passing 2-in. screen	100 per cent
Passing $\frac{1}{4}$-in. screen	30 to 100 "

(*b*) The material, if any, retained on the $\frac{1}{4}$-in. screen shall be uniformly graded from the maximum size present to $\frac{1}{4}$ in.

(*c*) The material passing the $\frac{1}{4}$-in. screen shall conform to the following requirements:

Total sand	50 to 80 per cent
Sand retained on 60-mesh	30 to 60 "
Silt	5 to 20 "
Clay	15 to 30 "

Methods of Testing. 3. The tests for the mechanical analysis of the sand, clay, natural sand-clay or topsoil mixtures shall be made in accordance with the Tentative Method of Mechanical Analysis of Subgrade Soils (Serial Designation: D 137 - 23 T) of the American Society for Testing Materials,[2] except that the determination of the percentage of suspension clay may be omitted and the percentage of total clay may be calculated by difference as follows:

100 − (Percentage of Sand + Percentage of Silt) = Percentage of Clay.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] See p. 749.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 10 TO 15 PENETRATION, FOR THE MANUFACTURE OF ASPHALT BLOCK.[1]

Serial Designation: D 133 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec.......10 to 15

(*b*) Flash Point (open cup).....not less than 200° C. (392° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr............ ....not more than 1 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 160° C. (325° F.) as compared with penetration of asphalt cement before heating, not less than 50 per cent

(*d*) Ductility at 25° C. (77^1 F.)................5 cm. to 15 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride....... ....not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 23 T).[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T).[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 23 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[5] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 15 TO 25 PENETRATION, FOR THE MANUFACTURE OF ASPHALT BLOCK.[1]

Serial Designation: D 134 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec. . . . . 15 to 25

(*b*) Flash Point (Open Cup) . . . . . . not less than 200° C. (392° F.)

(*c*) Loss on Heating at 163° C. (325° F.), 50 g., 5 hr. . . . . not more than 1 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating, not less than 50 per cent

(*d*) Ductility at 25° C. (77° F.) . . . . 5 cm. to 20 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride . . . . not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 – 23 T).[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T).[4]

(*e*) *Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 – 23 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[5] See p. 754.

TENTATIVE SPECIFICATIONS

FOR

ASPHALT CEMENT, 25 TO 30 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC CONCRETE PAVEMENTS[1]

Serial Designation: D 163 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec. . . . . 25 to 30

(*b*) Flash Point (open cup) . . . . not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr. . . . . not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating, not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.) . . . . not less than 15 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride . . . . not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 23 T).[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 690.

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[1]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T).[2]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 – 23 T).[3]

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[1] 1921 Book of A.S.T.M. Standards

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[3] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 30 TO 40 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC CONCRETE PAVEMENTS[1]

Serial Designation: D 164 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements: **Properties.**

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec.........30 to 40

(*b*) Flash Point (open cup)......not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr...........................not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating, not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.)............not less than 25 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride...................not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials: **Methods of Testing.**

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 23 T).[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 690.

(c) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[1]

(d) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T).[2]

(e) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 – 23 T).[3]

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[1] 1921 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[3] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 40 TO 50 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC CONCRETE PAVEMENTS.[1]

Serial Designation: D 99 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922, 1923.

Properties

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec. . . . . 40 to 50

(*b*) Flash point (open cup) . . . . not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr. . . . . not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating . . not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.) . . . . not less than 30 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride . . . . not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 – 23 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 – 23 T).[5]

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[1] **Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.**

[2] **1921 Book of A.S.T.M. Standards.** [3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922). [5] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 50 TO 60 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC CONCRETE PAVEMENTS.[1]

Serial Designation: D 100 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922, 1923.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec......50 to 60

(*b*) Flash point (open cup)........not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.......................................not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.)............not less than 30 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride.......................................not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 23 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 23 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards. [3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922). [5] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 60 TO 70 PENETRATION, FOR USE IN SHEET ASPHALT, ASPHALTIC CONCRETE, AND ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 101 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922, 1923.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec. . . . . . . 60 to 70

(*b*) Flash point (open cup) . . . . not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr. . . . . not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating. . not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.) . . . . not less than 30 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride. . . . . not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 23 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 23 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[5] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 70 TO 90 PENETRATION, FOR USE IN ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 102 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922, 1923.

Properties. 1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F), 100 g., 5 sec........70 to 90

(*b*) Flash point (open cup).......not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr...not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.)............not less than 30 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride..not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 23 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 23 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards. [3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922). [5] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 90 TO 120 PENETRATION, FOR USE IN ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 103 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922, 1923.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec......90 to 120
(*b*) Flash point (open-cup)........not less than 175° C. (347° F.)
(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr...not more than 2 per cent
Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..not less than 60 per cent
(*d*) Ductility at 25° C. (77° F.)............not less than 30 cm.
(*e*) Proportion of bitumen soluble in carbon tetrachloride...................................not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open-Cup (Serial Designation: D 92 - 23 T);[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T);[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 23 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards. [3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922). [5] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT CEMENT, 120 TO 150 PENETRATION, FOR USE IN ASPHALT MACADAM PAVEMENTS.[1]

Serial Designation: D 135 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec.......120 to 150

(*b*) Flash point (open cup)......not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr............ ....not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.)............not less than 30 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride....... ....not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[2]

(*b*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 23 T).[3]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T.).[4]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 23 T).[5]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards. [3] See p. 690.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922). [5] See p. 754.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR FOR SURFACE TREATMENT, COLD APPLICATION.[1]

Serial Designation: D 104 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Properties.

1. The tar shall conform to the following requirements:[2]

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[3] 50 cc. at 40° C. (104° F.)..8 to 35

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than	7.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than	20.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than	30.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than	35.00 "
Residue, by weight	not less than	65.00 "

(*d*) Specific gravity at 25°/25° C. (77°/77° F.) of total distillate to 300° C. (572° F.)..........................not less than 1.01

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 60° C. (140° F.)

(*f*) Total Bitumen (Soluble in Carbon Disulphide)..88 to 97 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] Within the viscosity limits designated a material should be chosen to meet the local conditions of temperature, road conditions and climate. It is recommended that materials be called for under the following range and headings: Light 8–13, Medium 13–18, Heavy 18–25, extra heavy 25–35.

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 691*, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[3]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] See p. 694.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol Apparatus, which may be adopted later.

[3] 1921 Book of A.S.T.M. Standards

[4] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR FOR SURFACE TREATMENT, COLD APPLICATION.[1]

Serial Designation: D 105 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Properties.

1. The tar shall conform to the following requirements:[2]

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[3] 50 cc. at 40° C. (104° F.)...8 to 35

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 5.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 20.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 35.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 45.00 "
Residue, by weight	not less than 55.00 "

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 60° C. (140° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)........................not less than 95.00 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] Within the viscosity limits designated a material should be chosen to meet the local conditions of temperature, road conditions and climate. It is recommended that materials be called for under the following range and headings: Light 8–13, Medium 13–18, Heavy 18–25, Extra Heavy 25–35.

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 691*, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[3]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] See p. 694.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] 1921 Book of A.S.T.M. Standards

[4] See p. 751.

TENTATIVE SPECIFICATIONS

FOR

HIGH-CARBON TAR CEMENT FOR USE COLD IN REPAIR WORK (CUT-BACK PRODUCT).[1]

Serial Designation: D 106 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Properties. 1. The tar cement shall conform to the following requirements:[2]

(*a*) Water..........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[3] 50 cc. at 40° C. (104° F.)..35 to 80

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)..................	3.00 to 10.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)..................	8.00 to 20.00 “
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)..................	18.00 to 30.00 “
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)..................	not more than 35.00 “
Residue, by weight..................	not less than 65.00 “

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test.......................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)[4].............. ....78 to 95 per cent

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials. 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] It is recommended that materials be called for under the following range and headings: Light 35 to 60, Heavy 60 to 80. The heavy material may require heating before use and care should be taken to avoid foaming on account of the possible water content.

[4] The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified.

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 691*, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[3]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] See p. 694.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] 1921 Book of A.S.T.M. Standards.

[4] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR CEMENT FOR USE COLD IN REPAIR WORK (CUT-BACK PRODUCT).[1]

Serial Designation: D 107 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Properties.

1. The tar cement shall conform to the following requirements:[2]

(*a*) Water........................not more than 2.00 per cent

(*b*) Specific viscosity, Engler,[3] 50 cc. at 40° C. (104° F.)..35 to 80

(*c*) Distillation test on water-free material:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	3.00 to 10.00	per cent.
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	8.00 to 20.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	18.00 to 30.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 38.00	"
Residue, by weight	not less than 62.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)..............
...........................not less than 95 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials, except as specified in Paragraph (*b*).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] It is recommended that materials be called for under the following range and headings: Light 35 to 60, Heavy 60 to 80. The heavy material may require heating before use and care should be taken to avoid foaming on account of the possible water content.

(*a*) ***Percentage of Water:*** Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[1]

(*b*) *Specific Viscosity:*[2] Method contained in *Bulletin No. 691*, U. S. Department of Agriculture, the instrument being standardized by the Bureau of Standards. The results shall be reported as specific viscosity compared with water at 25° C. (77° F.).

(*c*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[3]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] See p. 694.

[2] The Engler test has not been standardized by the American Society for Testing Materials. Committees of the Society have under consideration the Saybolt Furol apparatus, which may be adopted later.

[3] 1921 Book of A.S.T.M. Standards

[4] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR FOR SURFACE TREATMENT, HOT APPLICATION.[1]

Serial Designation: D 108 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1921; Revised, 1923.

Properties

1. The tar shall conform to the following requirements:[2]

(*a*) Water .... 0.00 per cent

(*b*) Float test at 32° C. (89.6° F.) .... 60 to 150 sec.

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than	1.00 per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than	10.00 "
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than	15.00 "
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than	25.00 "
Residue, by weight	not less than	75.00 "

(*d*) Specific gravity at 25° C. (77° F.) of total distillate to 300° C. (572° F.) ....not less than 1.03

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test.....................not more than 65° C. (149° F.)

(*f*) Total Bitumen (Soluble in Carbon Disulfide)[3]. ....78 to 95 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified.

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[1]

(*b*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[2]

(*d*) *Float Test:* Tentative Method of Float Test for Bituminous Road Materials (Serial Designation: D 139 – 23 T);[3]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] See p. 694.

[2] 1921 Book of A.S.T.M. Standards.

[3] See p. 756.

[4] See p. 751.

TENTATIVE SPECIFICATIONS

FOR

LOW-CARBON TAR FOR SURFACE TREATMENT, HOT APPLICATION.[1]

Serial Designation: D 109 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Properties.

1. The tar shall conform to the following requirements:[2]

(*a*) Water....................................0.00 per cent

(*b*) Float test at 32° C. (89.6° F.)..................60 to 150 sec.

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 1.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 4.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 13.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 26.00	"
Residue, by weight	not less than 74.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)..............
..............................not less than 95 per cent

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 - 23 T);[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] See p. 694.

(*b*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[1]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[1]

(*d*) *Float Test:* Tentative Method of Float Test for Bituminous Road Materials (Serial Designation: D 139 – 23 T);[2]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[3]

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[1] 1921 Book of A.S.T.M. Standards

[2] See p. 756.

[3] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON TAR CEMENT.[1]

Serial Designation: D 110 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

1. These specifications cover material suitable for use in the construction of tar macadam and tar concrete pavements. **Scope.**

2. The tar cement shall conform to the following requirements:[2] **Properties.**

(*a*) Water.................................0.00 per cent

(*b*) Softening point[3] (Ring-and-Ball Method)..30 to 40° C. (86 to 104° F.)[4]

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than 1.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than 2.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than 10.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than 20.00	"
Residue, by weight	not less than 80.00	"

(*d*) Specific gravity at 25°/25° C. (77°/77° F.) of total distillate to 300° C. (572° F.)............................not less than 1.03

(*e*) Softening point (Ring-and-Ball Method) of residue from distillation test.......................not more than 65° C. (149° F.)

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] If desired, a float test may be substituted for the softening point test, in which case the requirements shall be as follows: Float Test at 50° C. (122° F.), 100 to 220 sec.

[4] The specification range for softening point, within the above limits, should be 5° C. for any given locality, for example, 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 sec.; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 sec.

(*f*) Total Bitumen (Soluble in Carbon Disulfide)[1]..78 to 95 per cent

Methods of Testing. 3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[2]

(*b*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[3]

(*c*) *Softening Point:* Standard Method of Tests for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[3]

(*d*) *Float Test:* Tentative Method of Float Test for Bituminous Road Materials (Serial Designation: D 139 – 23 T);[4]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[5]

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[1] The specification range for total bitumen covers a wide variety of materials. If products from vertical retort or low-carbon coke-oven tars are desired, a range of 88 to 95 per cent should be specified. If high-carbon coke-oven or mixtures of coke-oven and gas-house tars are desired, a range of 78 to 88 per cent should be specified.

[2] See p. 694.

[3] 1921 Book of A.S.T.M. Standards

[4] See p. 756.

[5] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON TAR CEMENT.[1]

Serial Designation: D 111 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Scope. 1. These specifications cover material suitable for use in the construction of tar macadam and tar concrete pavements.

Properties. 2. The tar cement shall conform to the following requirements:[2]

(*a*) Water....................................0.00 per cent

(*b*) Softening point[3] (Ring-and-Ball Method)..30 to 40° C. (86 to 104° F.)[4]

(*c*) Distillation test:

Total Distillate, by weight, 0 to 170° C. (32 to 338° F.)	not more than	1.00	per cent
Total Distillate, by weight, 0 to 235° C. (32 to 455° F.)	not more than	2.00	"
Total Distillate, by weight, 0 to 270° C. (32 to 518° F.)	not more than	10.00	"
Total Distillate, by weight, 0 to 300° C. (32 to 572° F.)	not more than	20.00	"
Residue, by weight	not less than	80.00	"

(*d*) Softening point (Ring-and-Ball Method) of residue from distillation test........................not more than 65° C. (149° F.)

(*e*) Total Bitumen (Soluble in Carbon Disulfide)...not less than 95 per cent

Methods of Testing. 3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] If desired, a float test may be substituted for the softening point test, in which case the requirements shall be as follows: Float Test at 50° C. (122° F.), 100 to 220 sec.

[4] The specification range for softening point, within the above limits, should be 5° C. for any given locality, for example, 30 to 35° C. for cold climates, equivalent to a float test at 50° C. of 100 to 160 sec.; 35 to 40° C. for warm climates, equivalent to a float test at 50° C. of 160 to 220 sec.

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[1]

(*b*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[2]

(*d*) *Float Test:* Tentative Method of Float Test for Bituminous Road Materials (Serial Designation: D 139 – 23 T);[3]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] See p. 694.

[2] 1921 Book of A.S.T.M. Standards

[3] See p. 756.

[4] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
COAL-TAR PITCH FOR STONE BLOCK FILLER.[1]

Serial Designation: D 112 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922, 1923.

1. The coal-tar pitch shall conform to the following requirements:[2] **Properties.**

(*a*) Water ....0.00 per cent

(*b*) Softening point[3] (Cube-in-Water Method)..46 to 57° Cl (115 to 135° F.)

(*c*) Distillation test:

Total Distillate, by weight, 0 to 300° C.
(32 to 572° F.)..................not more than 10.00 per cent.
Residue, by weight.................. not less than 90.00 "

(*d*) Specific gravity at 25°/25° C. (77°/77° F.) of total distillate to 300° C. (572° F.) ....not less than 1.03

(*e*) Softening point (Cube-in-Water Method) of residue from distillation test...................not more than 75° C. (167° F.)

(*f*) Ductility at 50 to 100 penetration, at 25° C. (77° F.).......................................not less than 50 cm.

NOTE.—The penetration of the pitch shall be brought within the range of 50 to 100 penetration by heating in an open vessel with frequent stirrings at a temperature of not over 350° F.

(*g*) Total Bitumen (Soluble in Carbon Disulfide)..65.00 to 80.00 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] All tests shall be made on the sample as received, including the distillation test, and the results reported on a dry basis.

[3] The Softening Point (Cube-in-Water Method) specified should have a range of not over 10° F. within the above limits. The range, within the limits of 115 to 135° F. should vary with the use of the material, for example, if used in admixture with sand, in a northern locality or a southern locality. The softening point range, within the above limits, should also vary according to the character of the paving.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T);[1]

(*b*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20);[2]

(*c*) *Softening Point:* Standard Method of Test (for Softening Point of Tar Products (Cube-in-Water Method) Serial Designation: D 61);[2]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T);[3]

(*e*) *Total Bitumen:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] See p. 694.

[2] 1921 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[4] See p. 751.

TENTATIVE METHOD OF MECHANICAL ANALYSIS
OF
SUBGRADE SOILS.[1]

Serial Designation: D 137 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

Scope.

1. This method covers the determination of the amount of sand, silt, clay and suspension clay[2] in subgrade soils.

Treatment of Sample.

2. The sample as received shall be dried in an oven at a temperature not to exceed 100° C. (212° F.) and shall then be broken up in a mortar by means of a rubber-covered pestle, care being taken not to break any fragments of rock or sand. The sample shall then be passed through a $\frac{1}{4}$-in. screen and the material passing this screen further pulverized by rolling out in a thin layer on a rubber pad, using a rubber-covered roller.

Apparatus.

3. The apparatus shall consist of a wide-mouthed cylindrical glass jar of at least 10 liters capacity; a soil centrifuge with a four or eight-tube head of such diameter that a speed of 1500 r.p.m. will exert a centrifugal force approximately 500 times the force of gravity; four centrifuge tubes of 100-cc. capacity; and a chemical balance sensitive to 0.001 g.

Procedure.

4. By the method of quartering, a sample weighing approximately 25 g. shall be selected and placed in a beaker with approximately 500 cc. of distilled water, gradually brought to the boiling point and shall then be allowed to stand for about 24 hours. Care should be taken not to boil for more than two or three minutes, as continued boiling tends to cause coagulation. After standing for approximately 24 hours, the material in the beaker shall be thoroughly brushed and dispersed with a stiff brush for two or three minutes and then allowed to stand for eight minutes. The supernatant liquid shall then be de-

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] **The determination of the percentage of suspension clay by this method will include any water. soluble material present which may be determined separately if desirable.**

canted to a depth of 8 cm. from the surface of the liquid into a vessel having a capacity of about 10 liters. About 500 cc. of ammoniated water (concentration 1 : 500) shall be added to the material remaining in the beaker and the brushing repeated as before. After standing for eight minutes, the supernatant liquid shall be decanted into the large vessel. This process shall be repeated until the supernatant liquid becomes clear after eight minutes sedimentation. The sand and silt will have become separated from the clay and suspension clay, which are contained in the large vessel. The material in the beaker shall be transferred to an evaporating dish, dried in an oven to constant weight at a temperature of 100° C. (212° F.), cooled, and a mechanical analysis made, using 20 50, 100 and 200-mesh sieves. The material retained on each sieve shall be recorded as a percentage of the original 25-g. sample, and that which passes the 200-mesh sieve shall be recorded as the percentage of silt in the original sample.

The volume of the liquid in the large vessel shall be brought up to at least 10 liters by the addition of ammoniated water, and the vessel thoroughly shaken until all material is in suspension. Seventy cubic centimeters shall then be siphoned from this vessel at a depth of about one-half the total depth of the liquid into each of four centrifuge tubes. The tubes shall then be mounted in the centrifuge and run for 30 minutes at a speed which, for the diameter of the head used, will exert a centrifugal force approximately 500 times the force of gravity. The material which has been thrown out of the liquid by centrifuging shall be classified as clay and that which remains in suspension as suspension clay. The solution containing the suspension clay shall be decanted, evaporated to dryness, and the weight of the suspension clay determined. The clay remaining in the tube shall also be dried and weighed.

The weight of suspension clay is determined from the liquid in four tubes, or 280 cc.; consequently this weight must be multiplied by the factor obtained by dividing the total volume used by 280 cc. in order to obtain the total amount of suspension clay in the original 25-g. sample. The weight of clay is determined from the clay in one tube, or 70 cc.; therefore the total volume divided by 70 cc. gives the factor by which this weight should be multiplied to give the total clay in the original 25-g. sample. The total weights of clay and suspension clay thus obtained shall be converted into percentages of the original 25-g. sample.

TENTATIVE METHOD OF TEST
FOR
THE DETERMINATION OF BITUMEN[1]

Serial Designation: D 4 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Scope. 1. Bitumen may usually be expeditiously and accurately determined by Method No. 1, Section 5. In the case of certain native asphalts containing finely divided mineral matter, the mineral residue is not easily retained by the filter and it is necessary to resort to Method No. 2, Section 6, in order to obtain accurate results. Method No. 2 shall not be used unless the filter clogs unduly or unless the mineral matter passing through the filter exceeds 0.5 per cent. In every case the report shall indicate whether Method No. 1 or Method No. 2 has been employed.

I. APPARATUS

2. The apparatus shall consist of the following:

(*a*) Gooch crucible, approximately 4.4 cm. in width at the top, tapering to 3.6 cm. at the bottom, with a depth of 2.5 cm.;
(*b*) Filtering flask;
(*c*) Rubber stopper;
(*d*) Filter tube;
(*e*) Section of rubber tubing to hold the Gooch crucible on the filter tube;
(*f*) Asbestos (amphibole) cut in pieces not exceeding 1 cm. in length, shredded and shaken up with water;
(*g*) Two 150-cc. Erlenmeyer flasks;
(*h*) Bunsen burner;
(*i*) Drying oven;
(*j*) Suction pump;

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

This method, when adopted as standard, will supersede the present Standard Method of Test for Soluble Bitumen (Serial Designation: D 4 - 11), 1921 Book of A.S.T.M. Standards.

(*k*) Rubber tubing;
(*l*) Analytical balance;
(*m*) Desiccator.

II. PREPARATION OF SAMPLE

3. The sample shall be representative and if it contains more than 2 per cent of water it shall be dehydrated by distillation in a copper still in accordance with the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Materials (Serial Designation: D 20) of the American Society for Testing Materials,[1] the water-free distillate being returned to the residue. If the material is hard and brittle, it may be ground and dried at a temperature below the temperature of volatilization of the material.

III. PROCEDURE

Preparation of Gooch Crucible.

4. The Gooch crucible shall be set in the filter tube inserted in the stopper of the filtering flask. The flask shall be connected with the suction pump. Before suction shall be applied, the crucible shall be filled with asbestos suspended in water which shall be allowed to partly settle in the crucible. A light suction shall be applied to draw off the water, leaving a firm mat of asbestos in the crucible. More suspended asbestos shall be added and the process repeated until a felt is built up that barely transmits light. The felt shall then be thoroughly washed with water, dried in a drying oven, and ignited over a Bunsen burner. The crucible shall then be cooled in a desiccator and weighed.

(*a*) *Method No. 1*

Procedure No. 1.

5. An amount of material which shall contain approximately one gram of bitumen shall be weighed into a tared Erlenmeyer flask. One hundred cubic centimeters of chemically pure carbon disulfide shall be added to the flask in small portions with continued agitation until all lumps disappear and nothing adheres to the bottom. The flask shall be corked and set aside for fifteen minutes.

The Gooch crucible shall be set up again with the suction flask and the carbon disulfide solution carefully decanted through the asbestos felt. No sediment shall be allowed to go onto the filter. A small amount of carbon disulfide shall be used to wash down the sides of the flask and then the precipitate shall be brought onto the felt and the flask scrubbed with a feather if necessary to remove all precipitate. The contents of the crucible shall be washed with carbon disulfide until the washings are colorless. Suction shall be applied to the crucible to remove the carbon disulfide. The crucible shall be dried in the oven at 100 to 125° C. for twenty minutes, cooled in the desiccator and weighed.

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[1] 1921 Book of A.S.T.M. Standards.

In case insoluble matter adheres to the flask, the flask shall be dried and weighed and the increase in weight over the original weight shall be added to the weight of insoluble matter in the crucible.

The crucible shall be ignited at a red heat and after thorough ignition, cooled and weighed.

The weight of substance taken, minus the total weight of matter insoluble in carbon disulfide, is the total bitumen. The weight of material after ignition is ash.

(*b*) *Method No. 2*

Procedure No. 2.

6. Material shall be weighed out in the same way as in (*a*) Method No. 1 (Section 5) into a tared Erlenmeyer flask, and treated with 100 cc. of chemically pure carbon disulfide.

The flask shall be loosely corked and shaken at intervals until all large particles of material have been broken down. The flask shall be left undisturbed for 48 hours. The solution shall be decanted into a similar tared flask, care being taken to disturb as little of the residue as possible. The first flask shall be treated again with fresh carbon disulfide as before and left undisturbed for 48 hours. The solution from the second flask shall then be carefully decanted upon the Gooch crucible without use of vacuum, and this shall be followed by the solution from the first flask. The filter shall be washed with fresh carbon disulfide. The residue remaining in each flask shall be shaken again with fresh carbon disulfide and allowed to settle for 24 hours. The solution from both flasks shall then be decanted through the filter and the residues remaining in the flasks shall be washed again with carbon disulfide, the solution decanted and the process repeated until the washings are practically colorless. The temperature shall be maintained between 20 and 25° C.

The crucible and both flasks shall be dried at 100 to 125° C. and weighed. The filtrate containing the bitumen shall be evaporated, the bituminous residue burned, and the weight of the ash thus obtained added to that of the residue in the two flasks and the crucible. The sum of these weights deducted from the weight of substance taken is the weight of bitumen.

TENTATIVE METHOD OF TEST
FOR
THE DETERMINATION OF PROPORTION OF BITUMEN SOLUBLE IN CARBON TETRACHLORIDE[1]

Serial Designation: D 165 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

I. APPARATUS

Apparatus. 1. The apparatus shall consist of the following:

(*a*) Gooch Crucible, approximately 4.4 cm. in width at the top, tapering to 3.6 cm. at the bottom, with a depth of 2.5 cm.

(*b*) Filtering flask;

(*c*) Rubber stopper;

(*d*) Filter tube;

(*e*) Section of rubber tubing to hold the Gooch crucible on the filter tube;

(*f*) Asbestos (amphibole) cut in pieces not exceeding 1 cm. in length, shredded and shaken up with water;

(*g*) Two 150-cc. Erlenmeyer flasks;

(*h*) Bunsen burner;

(*i*) Drying oven;

(*j*) Suction pump;

(*k*) Rubber tubing;

(*l*) Analytical balance;

(*m*) Desiccator.

II. PREPARATION OF SAMPLE

2. The sample shall be representative and if it contains more than 2 per cent of water it shall be dehydrated by distillation in a copper still in accordance with the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Materials (Serial Designation: D 20) of the American Society for Testing Materials,[2] and water-

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] 1921 Book of A.S.T.M. Standards.

free distillate returned to the residue. If the material is hard and brittle, it may be ground and dried at a temperature below the temperature of volatilization of the material.

III. PROCEDURE

Preparation of Gooch Crucible.

3. The Gooch crucible shall be set in the filter tube inserted in the stopper of the filtering flask. The flask shall be connected with the suction pump. Before suction is applied, the crucible shall be filled with asbestos suspended in water which shall be allowed to partly settle in the crucible. A light suction shall be applied to draw off the water, leaving a firm mat of asbestos in the crucible. More suspended asbestos shall be added and the process repeated until a felt is built up that barely transmits light. The felt shall then be thoroughly washed with water, dried in a drying oven, and ignited over a Bunsen burner. The crucible then shall be cooled in a desiccator and weighed.

Procedure.

4. An amount of material which shall contain approximately one gram of bitumen shall be weighed into a tared Erlenmeyer flask. One hundred cubic centimeters of chemically pure carbon tetrachloride shall be added to the flask in small portions with continued agitation until all lumps disappear and nothing adheres to the bottom. The flask shall be corked and set aside in subdued light for at least 12 hours.

The Gooch crucible shall be set up again with the suction flask and the carbon tetrachloride solution carefully decanted through the asbestos felt. No sediment shall be allowed to go onto the filter. A small amount of carbon tetrachloride shall be used to wash down the sides of the flask and then the precipitate shall be brought onto the felt and the flask scrubbed with a feather if necessary to remove all precipitate. The contents of the crucible shall be washed with carbon tetrachloride until the washings are colorless. Suction shall be applied to the crucible to remove the carbon tetrachloride. The crucible shall be dried in the oven at 100 to 125 C. for twenty minutes, cooled in the desiccator, and weighed.

In case insoluble matter adheres to the flask, the flask shall be dried and weighed and the increase in weight over the original weight shall be added to the weight of insoluble matter in the crucible.

The proportion of bitumen soluble in carbon tetrachloride shall be reported on the basis of total bitumen taken as 100.

$$\begin{array}{c}\text{Proportion of Bitumen Soluble}\\ \text{in Carbon Tetrachloride.}\end{array} = \frac{\text{Bitumen Soluble in Carbon Tetrachloride}}{\text{Total Bitumen}}$$

TENTATIVE METHOD OF FLOAT TEST
FOR
BITUMINOUS ROAD MATERIALS[1]

Serial Designation: D 139 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1922; Revised, 1923.

I. APPARATUS.

Float. 1. The float (Fig. 1) shall be made of aluminum or aluminum alloy and shall be in accordance with the following requirements:

	Minimum.	Normal.	Maximum.
Weight of float, g.	37.80	37.95	38.10
Total height of float, mm.	34.0	35.0	36.0
Height of rim above lower side of shoulder, mm.	26.5	27.0	27.5
Thickness of shoulder, mm.	1.3	1.4	1.5
Diameter of opening, mm.	11.0	11.1	11.2
Height of rim above water with load of 5.5 g., mm.	7.0	8.5	10.0

Collar. 2. The collar (Fig. 1) shall be made of brass and shall be in accordance with the following requirements:

	Minimum.	Normal.	Maximum.
Weight of collar, g.	9.9	9.95	10.0
Over-all height of collar, mm.	22.3	22.5	22.7
Inside diameter at bottom, mm.	12.78	12.80	12.82
Inside diameter at top, mm.	9.66	9.68	9.70

The top of the collar shall screw up tightly against the lower side of the shoulder.

Thermometer. 3. The thermometer shall conform to the following specifications:

Total length	370 – 400 mm.	(14.57 – 15.75 in.)
Diameter	6.5 – 7.5 "	(0.256 – 0.295 ")
Bulb length	Not over 14 "	(Not over 0.55 ")
Bulb diameter	4.5 – 5.5 "	(0.177 – 0.217 ")

The scale shall be engraved upon the stem of the thermometer, shall be clear cut and distinct, and shall run from 0 to 80° C. (32 to 176° F.) in $\frac{1}{5}$° C. divisions. It shall commence not less than 75 mm. (2.95 in.) above the bottom of the bulb. The thermometer shall be furnished with an expansion chamber at the top and have

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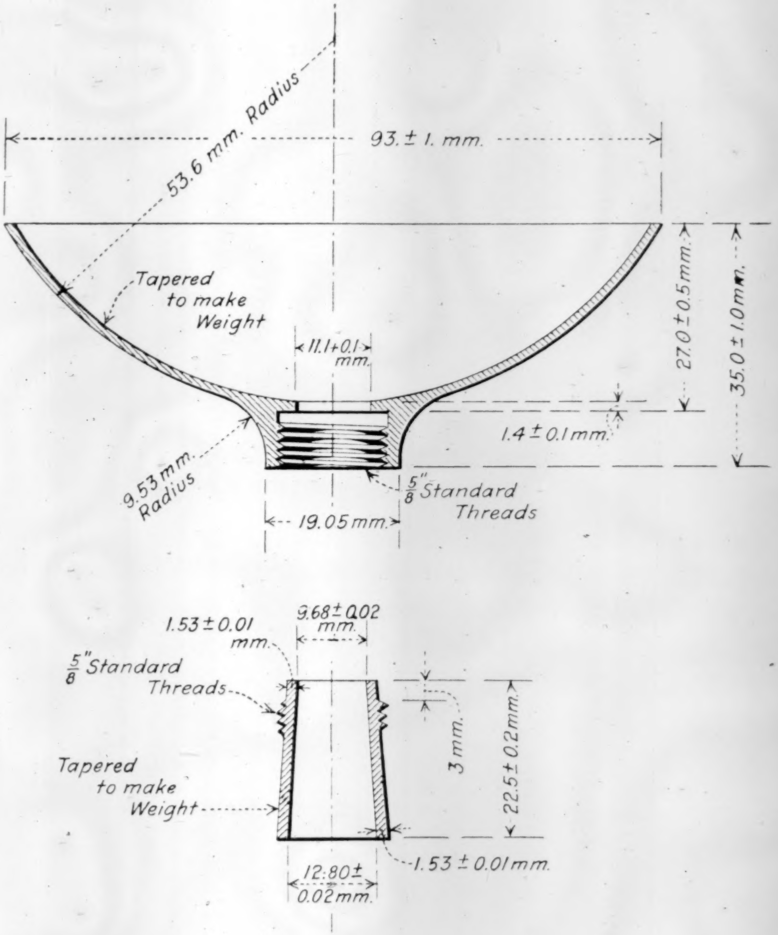
[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.


53.6 mm. Radius
93. ± 1. mm.
Tapered to make Weight
11.1+0.1 mm.
27.0 ± 0.5 mm.
35.0 ± 1.0 mm.
1.4 ± 0.1 mm.
9.53 mm. Radius
5/8" Standard Threads
19.05 mm.
1.53 ± 0.01 mm.
9.68 ± 0.02 mm.
5/8" Standard Threads
Tapered to make Weight
3 mm.
22.5 ± 0.2 mm.
1.53 ± 0.01 mm.
12.80 ± 0.02 mm.

Weight of Float 37.95 ± 0.15 g.
" " Collar 9.95 ± 0.05 g.

FIG. 1.—Float and Collar

a ring for attaching tags. It shall be made of a suitable quality of glass and be so annealed as not to change its readings under conditions of use. It shall be correct to 0.25° C. (0.45° F.) as determined by comparison at full immersion with a similar thermometer calibrated at full immersion by the U. S. Bureau of Standards.

Bath.

4. The minimum diameter of the bath shall be twice the diameter of the float; the minimum depth of water shall be equal to the diameter of the bath.

II. PREPARATION OF SAMPLE.

Preparation of Sample.

5. The sample shall be completely melted at the lowest possible temperature, heating only sufficiently to bring the product into a fluid condition but not above 350° F., and stirred thoroughly until it is homogeneous and free from air bubbles.

The brass collar shall be placed with the smaller end on a brass plate which has been previously amalgamated with mercury by first rubbing it with a dilute solution of mercuric chloride or nitrate and then with mercury. The sample shall be poured into the collar in any convenient way until slightly more than level with the top. It shall be cooled to room temperature, placed in water maintained at 5° C. for 5 minutes, after which the surplus material shall be removed by means of a spatula, or steel knife, which has been slightly heated. The collar and plate shall then be placed in tin cup containing ice water maintained at 5° C., ± 1° C., and left in this bath for at least 15 minutes.

III. PROCEDURE.

Procedure.

6. (*a*) The bath shall be filled with water and the water heated to the temperature at which the test is to be made. This temperature shall be accurately maintained and shall at no time throughout the test be allowed to vary more than 0.5° C. from the temperature specified.

(*b*) After the material to be tested has been kept in the ice water for not less than 15 minutes nor more than 30 minutes, the collar with its contents shall be removed from the plate and screwed into the aluminum float and immersed in water at 5° C. for one minute. Any water shall then be removed from the inside of the float and the latter immediately floated in the warm bath. As the plug of material becomes warm and fluid, it is forced upward and out of the collar until the water gains entrance into the saucer and causes it to sink.

(*c*) The time in seconds between placing the apparatus on the water and when the water breaks through the material shall be determined by means of a stop watch, and shall be taken as a measure of the consistency of the material under examination.

NOTE.—Special precaution should be taken to insure the collar fitting tightly into the float and to see that there is no seepage of water between the collar and float during the test.

TENTATIVE METHODS OF SAMPLING BITUMINOUS MATERIALS[1]

Serial Designation: D 140 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

General Directions.

1. Samples may be taken for either of two purposes:

(*a*) To represent as nearly as possible an average of the bulk of the material sampled.

(*b*) To ascertain the maximum variation in characteristics which the material may possess. In either case they shall be obtained by methods hereinafter described.

2. (*a*) Care shall be taken that the samples are not contaminated with dirt or any other extraneous matter and that the sample containers are perfectly clean and dry before filling.

(*b*) Immediately after filling, the sample containers shall be tightly closed and properly marked for identification on the container itself or on a linen tag attached to the container.

Time and Place.

3. (*a*) Whenever practical, bituminous materials shall be sampled at the point of manufacture, and at such time as to allow the tests, controlling acceptance or rejection, to be made in advance of shipment.

(*b*) When impracticable to take samples at the point of manufacture, they should be taken from the shipment immediately upon delivery.

Size of Samples.

4. For routine laboratory examination of acceptability of a given lot, not less than one quart of material should be submitted which should be representative of the average sample collected as hereinafter described.

Containers.

5. Containers for liquid bituminous materials shall be small-mouth cans with cork-lined screw caps. Containers for semi-solid and solid materials shall be friction top cans.

I. SAMPLING AT PLACE OF MANUFACTURE.

From Bulk Storage.

6. The inlet and outlet to the storage tank shall be sealed and a 1-gal. sample drawn from the top, middle and bottom contents. The sample may be taken from drain cocks on the side of the tank, if such

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

are available. Enough material should be discarded to insure a representative sample. Otherwise, samples may be taken by lowering, weighted bottles or cans into the material. The bottle or can should be fitted with a stopper which can be removed by a string or wire attached to it after it has been lowered to the proper depth. The three samples from bulk storage shall be tested separately for consistency in order to detect stratification. They may then be combined and thoroughly mixed for other tests that may be required.

Sampling during Loading.

7. Where tank cars, distributors or barrels are being filled, samples may conveniently be taken from the pipe line through which the material is flowing, as hereinafter described.

(*A*) *When Material is Pumped Under Pressure.*

8. The sampling pipe shall be inserted into a rising section of the pipe line on the discharge side of the pump. The sampling pipe shall be not more than one-eighth the diameter of the line pipe and its opening should be turned at an angle of 90 deg. facing the flow of the liquid. This pipe shall be provided with a plug cock and shall discharge into a receiving drum of 50-gal. capacity. The plug cock shall be so adjusted that there is a steady continuous flow of bituminous material through it and shall be so regulated that the receiver will fill in the same time that is required to make the entire pumping. In the case of semi-solid materials, the receiver shall be provided with a steam coil which shall keep the contents at a temperature just above the liquefying point. At completion of the pumping, the receiver shall be thoroughly agitated, and a 1-qt. sample taken therefrom. The sampling shall be so regulated that for each 1000 gal. of material pumped, at least 1 gal. of sample is taken; but 40 gal. shall be the limit required for any one cargo.

Care should be taken that the drip cock, after once having been set, allows a constant flow during the pumping.

This method is also applicable to gravity flows where the pipe line is completely filled by the outflowing liquid and has a rising section.

(*B*) *When Materials Flow by Gravity.*

9. Materials flowing by gravity through pipes which are not completely filled may be sampled by taking dipperfuls at the outlet at frequent and regular intervals. These samples shall be combined and the total sample shall be not less than 0.1 per cent of the whole material. The samples shall be collected in a receiver and resampled as described in Section 8.

II. SAMPLING AT POINT OF DELIVERY.

Tank Cars.

10. Samples may be taken by means of a weighted bottle or can, as described in Section 6, or from the unloading pipe line as described in Section 7.

Liquid bituminous materials shall be sampled before heating. Semi-solid or solid bituminous materials shall be rendered fluid by heating. Sampling should be so conducted as to eliminate the possibility of adventitious water resulting from leaky steam heating coils, rain or snow.

Distributors.

11. Samples may be taken from distributors by means of a weighted bottle or can, as described in Section 6. One sample shall be sufficient.

Barrels, Drums and Cakes.

12. (*a*) *Semi-Solid or Solid Materials.*—Where the lot of material to be sampled is obviously from a single run or batch of the producer, one package or cake shall be selected at random and sampled as described in the following paragraph. Where the lot of material to be sampled is not obviously from a single run or batch of the producer, or where the single sample selected as described above fails on test to conform to the requirements of the specifications, a number of packages or cakes shall be selected at random equivalent to the cube root of the total number of packages or cakes in the lot. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

PACKAGES OR CAKES IN SHIPMENT	PACKAGES OR CAKES SELECTED	PACKAGES OR CAKES IN SHIPMENT	PACKAGES OR CAKES SELECTED
2 to 8	2	217 to 343	7
9 to 27	3	344 to 512	8
28 to 64	4	513 to 729	9
65 to 125	5	730 to 1000	10
126 to 216	6	1001 to 1331	11

Samples shall be taken from at least 3 in. below the surface and at least 3 in. from the side of the container or cake or from the center of a cake. A clean hatchet may be used if the material is hard enough to shatter and a broad stiff putty knife if the material is soft. An auger, or brace and $\frac{3}{4}$-in. bit, or other suitable means may also be used. When more than one package or cake in a lot is sampled, each individual sample shall be not less than $\frac{1}{4}$ lb. in weight. When the lot of material is obviously from a single run or batch of the producer, all samples from the lot shall be melted and thoroughly mixed, and an average sample taken from the combined material for examination. In case more than a single run or batch of the producer is present and the batches can be clearly differentiated, a composite sample shall be prepared for examination from each batch. Where it is not possible to differentiate between the various batches each sample shall be examined separately.

(*b*) *Liquid Materials.*—Samples of liquid bituminous materials from barrels or drums shall be secured by taking 1 qt. of material from packages selected at random according to the cube root method described in Paragraph (*a*). When the lot of material is obviously from a single run or batch of the producer the samples shall be combined and thoroughly mixed and an average sample taken from the combined material. In case more than one run or batch is present and can be clearly differentiated, a composite sample shall be prepared from each batch. Where it is impossible to differentiate between the various batches or runs, each sample shall be examined separately.

Bulk and Bags.

13. Solid bituminous materials in crushed fragments or powder, such as gilsonite, grahamite, etc., shall be sampled in accordance with the Standard Method of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials.[1]

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[1] 1921 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS
FOR
GAS AND COKING COALS[1]

Serial Designation: D 166 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Scope. 1. Gas and coking coals must yield both merchantable gas and coke when distilled in a retort or oven by commercial methods. The type of coals may vary within rather wide limits according to the treatment in the retort and the market for the products. These specifications, therefore, merely give the limits within which gas and coking coals will usually fall, and indicate the circumstances under which further restrictive conditions should be imposed.

I. SAMPLING AND ANALYSIS

Sampling. 2. The coal shall be sampled in accordance with the Standard Methods of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials.[2]

Analysis. 3. Analyses of the coal, when required, shall be made in accordance with the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) of the American Society for Testing Materials.[2]

II. CHEMICAL AND PHYSICAL PROPERTIES

The carbon ratio, that is, the ratio of fixed carbon to volatile matter, while not entirely reliable, is the best simple index to the behavior of the coal when carbonized. The carbon ratio in the case of gas coals will vary from 1.4 to 2.0 and for coking coals from 1.4 to 5.0. The latter includes a wide range of coals varying from high volatile gas coal to low volatile or "smokeless" coal.

Mine Moisture. 4. (*a*) The percentage of moisture in the coal as mined shall be subject to agreement by the purchaser and the seller.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[2] 1921 Book of A.S.T.M. Standards.

(*b*) In the absence of a definite agreement between the purchaser and the seller, the mine moisture in the coal as mined shall not exceed 4.0 per cent. The moisture shall be determined by the general average composition of coal from the mine in question and an analysis of each shipment shall not be required.

Fusion Point of Ash. 5. The fusion temperature of ash of coal, the coke from which is intended for domestic and industrial use, shall not be below 2200° F. In the case of coke for use in the manufacture of water gas, the fusion temperature of the ash of the coal shall preferably be higher than 2300° F. The fusion temperature of the ash shall be determined in accordance with the Standard Method of Test for Fusibility of Coal Ash (Serial Designation: D 22) of the American Society for Testing Materials.[1]

NOTE.—The fusion point of ash is not usually important for metallurgical work. It is important, however, in the case of coke for domestic and industrial furnace use and for the manufacture of water gas.

A. Special Requirements for Gas Coals

Volatile Matter. 6. Gas coal shall contain not less than 35.0 per cent of volatile matter when determined on the moisture and ash-free basis.

NOTE.—This is equivalent to 30.8 per cent volatile matter for a coal containing 12.0 per cent of combined ash and moisture.

Ash. 7. In the case of gas coals, the ash in the dry coal shall be not over 9 per cent.

Sulfur. 8. The composition of gas coal shall be such that the dry coke produced therefrom will contain not over 1.5 per cent of sulfur and the resultant gas will contain not more than 30 grains of sulfur, in the form of compounds other than hydrogen sulfide, per 100 cu. ft. of gas.

Quality of Coke 9. Gas coal shall be such that the coke produced therefrom will be of sufficient size and strength to be suitable for domestic use or for the manufacture of water gas.

NOTE.—These physical characteristics of coke are not amenable to simple explicit definition and must necessarily be left to the judgment of experienced operators.

B. Special Requirements for Coking Coals

Ash. 10. In the case of coking coals, the ash in the dry coal shall be not over 9 per cent.

Sulfur. 11. (*a*) If metallurgical coke is to be produced, the composition of the coking coal shall be such that the dry coke produced therefrom will not contain more than 1.0 per cent of sulfur in the case of foundry coke, and 1.3 per cent of sulfur in the case of blast-furnace coke.

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[1] A.S.T.M. Standards Adopted in 1923.

(*b*) If gas is to be sold for dometic use, the composition of the coking coal shall be such that the resultant gas will contain not more than 30 grains of sulfur, in the form of compounds other than hydrogen sulfide, per 100 cu. ft. of gas.

Phosphorus.

12. A limitation as to phosphorus, which may be required when coke is used for metallurgical purposes, shall be subject to agreement between the purchaser and the seller.

Shrinkage.

13. The composition of coking coal which is to be charged into a by-product oven without admixture shall be such that the coke produced therefrom will shrink sufficiently to permit of its being discharged from the oven without difficulty.

NOTE.—The mixing of coals for by-product coke-oven use is widely practiced, and such mixtures usually contain, as a very important component, low volatile or "smokeless" coking coals, which when carbonized alone would not give the requisite shrinkage.

Quality of Coke.

14. The composition of the coking coal shall be such that the coke produced therefrom will meet such requirements as to size, strength, and structure as are necessary for good practice in the industries using the coke.

NOTE.—These physical characteristics of coke are not amenable to simple explicit definition and must necessarily be left to the judgment of experienced operators.

TENTATIVE METHOD OF TEST
FOR
VOLUME OF CELL SPACE OF LUMP COKE[1]

Serial Designation: D 167 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Volume of Cell Space. 1. The percentage by volume of cell space of lump coke shall be calculated from the apparent specific gravity of the moisture-free lump coke and the true specific gravity of the moisture-free 200-mesh coke, as follows:

$$\text{Percentage of cell space} = 100 - 100\,\frac{\text{Apparent specific gravity}}{\text{True specific gravity.}}$$

A. Determination of Apparent Specific Gravity.

I. APPARATUS

Apparatus. 2. The apparatus for the determination of the apparent specific gravity of coke shall consist of the following:

(*a*) A suitable container not smaller than approximately 13 in. in height, 22 in. in length and 11 in. in width, or of equivalent size, provided with a spout consisting of a short $\frac{1}{2}$-in. nipple extending horizontally from the container about $2\frac{1}{2}$ in. below the top.

NOTE.—A wash boiler of suitable size to which a spout has been soldered answers the above description.

(*b*) A wire cage or basket of about $\frac{1}{2}$-in. square-mesh screen wire cloth provided with a cover and two long handles, suitable for holding the entire sample of coke and so made as to fit inside the container below the spout.

(*c*) A 3-gal. bucket or other vessel suitable for receiving the displaced water.

(*d*) A pan about 15 in. square and 3 in. in height or the equivalent for containing the coke during the determination of its weight.

(*e*) A scale sensitive to $\frac{1}{2}$ oz.

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[1] **Criticisms** of this Tentative Method are solicited and should be directed to Mr. W. A. Selvig, **Secretary** of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

II. SAMPLING

3. Each carload, or its equivalent, shall be considered a unit for sampling. **Unit of Sampling.**

4. (*a*) If the porosity test is desired on run-of-oven coke, the sample should be collected from the coke wharf in the case of by-product coke, while samples of beehive coke should be collected as it is delivered from the ovens. **Place of Sampling.**

(*b*) If the porosity test is desired on coke for furnace or cupola use, the sample should be representative of the material in question and collected at the point of delivery.

5. (*a*) *By-Product Coke.*—About 50 lb. of representative pieces of coke shall be selected from the coke wharf for each test. This is best accomplished by dividing the coke on the wharf into approximately equal areas, and selecting an equal number of pieces from each area. Each piece selected shall be approximately equal in length to one-half of the width of the coke-ovens, and shall show a "cauliflower" end produced at the walls of the ovens, and an "inner" end produced at the center of the ovens. **Sampling at Source.**

(*b*) *Beehive Coke.*—About 50 lb. of representative pieces of coke shall be selected for each test as the coke is drawn from the ovens. This is best done by selecting full-length pieces, or their equivalent, as the coke is being drawn from previously determined points in the oven, so that they include pieces from the front, sides, center, and back. If the individual pieces as taken from the ovens are too large and bulky, the 50-lb. sample shall be collected by removing three small pieces from each large piece—one from the top, the middle, and the bottom. The sample finally collected should be composed of an equal number of pieces showing top, middle and bottom.

6. *By-Product and Beehive Coke.*—The sample is best collected as the coke is delivered from the railroad cars into the bins. This may be accomplished by inserting a scoop of 10 to 15-lb. capacity in the coke stream at regular intervals during the period of unloading. The sample collected shall be large enough to give about 50 lb. of coke pieces, none of which would in any position pass through a 1-in. square-mesh screen. **Sampling at Delivery.**

NOTE.—Since the cage or basket is of ½-in. square-mesh screen wire cloth, it is necessary to have coke pieces that will remain in the cage when the cage is removed from the water.

As it is very difficult to collect a representative sample from coke exposed in bins and cars, care should be taken to take pieces representing the entire exposed area, if sampling must be done in this manner. This is best accomplished by dividing the exposed surface to be sampled into approximately equal areas, and selecting an equal number of pieces from each area. A 50-lb. sample of representative pieces shall be collected, none of which should in any position pass through a 1-in. square-mesh screen.

III. PROCEDURE

Procedure. 7. About 25 lb. of coke from the sample shall be selected so as to be representative of the material under consideration with regard to size, shape and general appearance. The coke shall be dried to constant weight at a temperature of from 105 to 200° C. The coke shall be weighed when cool, after shaking and brushing off any adhering dust.

A cork shall be placed in the spout of the container, which has been placed on a level and rigid base or floor. After the empty cage has been placed into the container, water at room temperature shall be poured into the container until the water level is above the spout. After the water has come to rest, the cork shall be removed from the spout and the excess water be permitted to drain out for one minute after the overflow stream starts to discharge drop by drop. The cork shall then be replaced and the cage removed from the water, care being taken to shake all adhering water back into the container. The weighed dried coke sample shall then be placed into the cage and after fastening the cover, the cage containing the coke shall be lowered into the water.

NOTE.—If there is not sufficient capacity in the container above the spout to retain the displaced water, some of the water may be drawn off into a weighed bucket, or other suitable vessel, by removing the cork from the spout while the coke is being lowered.

The cage shall be permitted to remain in the water for 15 minutes with occasional shaking to detach any air bubbles adhering to the surface of the coke, care being taken not to disturb the position of the container. At the end of the 15-minute period, during which the coke shall have been completely submerged at all times, after the water has come to rest, the cork shall be removed and the displaced water permitted to drain into a weighed bucket or other suitable vessel for 1 minute after the overflow stream starts to discharge drop by drop. The cork shall then be replaced, the cage containing the coke removed from the water and permitted to drain for 1 minute. The wet coke shall then be removed from the cage and weighed.

The weight of the displaced water, which has been caught in the bucket, shall then be determined.

8. The apparent specific gravity shall be calculated from the formula:

$$\text{Apparent specific gravity} = \frac{A}{B + (C - A)}$$

in which A = Weight of dry coke;
B = Weight of water displaced by wet coke; and
C = Weight of wet coke.

B. Determination of True Specific Gravity

IV. APPARATUS

Apparatus. 9. The apparatus for the determination of the true specific gravity of 200-mesh coke shall consist of a Hogarth's specific gravity bottle with side tubulure, having a capacity of about 100 cc. The bottle shall be accurately calibrated so that a table may be constructed giving the contents of the bottle at the room temperatures likely to occur in the laboratory.

NOTE.—This may be done conveniently from data in tables of corrections for determining the true capacities of glass vessels from the weight of water in air, as given in U. S. Bureau of Standards *Circular No. 19*, pp. 52 to 56 (1916).

V. PROCEDURE

Procedure. 10. A 10-g. portion of 200-mesh coke, which has been previously dried for 1 hour at 105° C., shall be carefully introduced into the specific gravity bottle with a sufficient quantity of distilled water to fill the bottle about one-half full. The bottle shall then be placed on a hot plate and the contents kept boiling for 1 hour, the specific gravity bottle being shaken frequently so as to wash down any coke adhering to the sides. After boiling for 1 hour, the bottle shall be removed from the plate, filled to the tubulure with recently boiled and cooled distilled water, and the stopper inserted. The bottle shall be permitted to stand until the contents have cooled to room temperature.

NOTE.—Cooling may be hastened by placing the bottle in water.

After the contents of the bottle have cooled to room temperature, the bottle shall be filled to slightly above the mark on the capillary of the stopper with recently boiled distilled water which has been cooled to room temperature.

NOTE.—This is conveniently done by inserting the end of the tubulure in a small beaker of the distilled water and applying a slight suction on the stopper.

The water level shall be adjusted to the mark on the capillary by touching a piece of filter paper to the end of the tubulure. The bottle shall then be wiped dry and weighed immediately. Immediately after the weighing, the stopper shall be removed and the temperature of the contents taken.

11. The true specific gravity shall be calculated from the formula:

$$\text{True specific gravity} = \frac{W}{W - (W' - P)}$$

in which W = Weight in grams of dry coke;

W' = Weight in grams of bottle + dry coke + water required to fill the bottle;

P = Weight in grams of bottle + water required to fill the bottle.

12. The differences in duplicate determinations shall be not more than the following:

Same analyst	0.01
Different analysts	0.02

TENTATIVE METHOD OF TEST
FOR
COKE RESIDUE OF CREOSOTE OIL[1]

Serial Designation: D 168 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Apparatus.

1. *Crucible.*—The crucible shall be of platinum and shall have a capacity of 20 to 30 cc. The cover of the crucible shall be of the inverted type, having a depth of about 1 cm., the wall tightly fitting the crucible except for a slight crease.

Procedure.

2. The residue resulting from the distillation test, carried out in accordance with the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials,[2] shall be poured directly into the tared crucible or into a tin box wherein it may be heated on a water or steam bath, but not over a flame. About 1 g. of the residue shall be weighed into the covered crucible and then placed on a platinum, nichrome, or fire-clay triangle over a Bunsen burner, with the bottom of the crucible 6 to 8 cm. from the top of the burner. The burner flame shall be regulated to a height of 20 cm. while burning free and the crucible shall be exposed to the full flame for 7 minutes. A Meeker burner may be used, or the crucible may be heated for several minutes in an electric furnace. Whatever the method of heating employed, the temperature during the entire 7-minute period shall be not less than 950° C. and should be as near that temperature as possible. At the end of this period the flame shall be removed, the crucible transferred to a desiccator and permitted to cool, after which it shall be weighed. The residue in the crucible after ignition shall be reported as "fixed carbon" (*i. e.*, coke).

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, Forest Products Laboratory, Madison, Wis.

This tentative method, when adopted as standard, will supersede Sections 19 and 20 of the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38 – 18), 1921 Book of A.S.T.M. Standards.

[2] 1921 Book of A.S.T.M. Standards.

Precautions. 3. The test shall be conducted in a part of the laboratory free from draughts.

Calculations. 4. The percentage of coke obtained in accordance with Section 2 shall be calculated on the basis of the original sample of oil.

Example.—With a retort distillation of 29 per cent of residue at 355° C., the residue containing 28 per cent of fixed carbon:

$$\text{Coke in oil} = \frac{29 \times 28}{100} = 8.1 \text{ per cent}$$

TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING BELOW GROUND LEVEL[1]

Serial Designation: D 40 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

Issued, 1917; Revised, 1922, 1923

Scope.

1. These specifications cover asphalt suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing below ground level, under uniformly moderate temperature conditions.[2]

2. The grade of asphalt covered in these specifications is suitable for damp-proofing and waterproofing foundations, tunnels, subways, etc.

I. SAMPLING.

Sampling.

3. The sampling shall be performed in accordance with the Tentative Methods of Sampling Bituminous Materials (Serial Designation: D 140 – 23 T) of the American Society for Testing Materials.[3]

II. PROPERTIES.

Properties.

4. The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Softening point by the Ring-and-Ball method.................115 to 145° F. (46.1 to 62.7° C.)

(*b*) Penetration at 25° C. (77° F.), 100 g., 5 sec.......................................50 to 100

(*c*) Flash point (open cup).......not less than 347° F. (175° C.)

(*d*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.....................not more than 2 per cent

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Such asphalt is not intended to be heated above 400° F. (204.4° C.) during its application.

[3] See p. 759.

(*e*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt before heating..........................not less than 60 per cent

(*f*) Ductility at 25° C. (77° F.)...................not less than 30 cm.

(*g*) Insoluble in carbon disulfide........not more than 1 per cent

III. METHODS OF TESTING.

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36).[1]

(*b*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[1]

(*c*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 – 23 T).[2]

(*d*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[1]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T).[3]

(*f*) *Insoluble in Carbon Disulfide:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[4]

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 690.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[4] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING ABOVE GROUND LEVEL[1]

Serial Designation: D 144 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923

Scope

1. These specifications cover asphalt suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing above ground level, where not exposed to a temperature exceeding 100° F. (37.7° C.).[2] It may be used below ground level.

2. The grade of asphalt covered in these specifications is suitable for damp-proofing and waterproofing railroad bridges, tanks, retaining walls, embankments, culverts, dams, conduits, etc.

I. SAMPLING.

Sampling.

3. The sampling shall be performed in accordance with the Tentative Methods of Sampling Bituminous Materials (Serial Designation: D 140 - 23 T) of the American Society for Testing Materials.[3]

II. PROPERTIES.

Properties.

4. The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*)	Softening point by the Ring-and-Ball method	150 to 200° F. (65.5 to 93.3° C.)
(*b*)	Penetration at 25° C. (77° F.), 100 g., 5 sec.	25 to 50
	Penetration at 0° C. (32° F.), 200 g., 60 sec.	not less than 10

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Such asphalt is not intended to be heated above 450° F. (232.2° C.) during its application.

[3] See p. 759.

(*c*) Flash point (open cup)........not less than 400° F. (204.4° C.)
(*d*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.......................not more than 1 per cent
(*e*) Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt before heating.................................not less than 60 per cent
(*f*) Ductility at 25° C. (77° F.) ....not less than 3 cm.
(*g*) Insoluble in carbon disulfide........ not more than 1 per cent.

III. METHODS OF TESTING.

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36).[1]

(*b*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[1]

(*c*) *Flash Point:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 23 T).[2]

(*d*) *Loss on Heating:* Standard Method of Test for loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[1]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 22 T).[3]

(*f*) *Insoluble in Carbon Disulfide:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 - 23 T).[4]

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[1] 1921 Book of A.S.T.M. Standards.

[2] See p. 690.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[4] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
HIGH-CARBON COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING BELOW GROUND LEVEL[1]

Serial Designation: D 42 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1917; REVISED, 1922, 1923

Scope. 1. These specifications cover high-carbon coal-tar pitch[2] suitable for use as a mopping-coat in damp-proofing or as a plying-cement in the construction of a membrane system of waterproofing below ground level, under uniformly moderate temperature conditions.[3]

2. The grade of high-carbon coal-tar pitch covered by these specifications is suitable for damp-proofing and waterproofing foundations, tunnels, subways, etc.

I. SAMPLING.

Sampling. 3. The sampling shall be performed in accordance with the Tentative Methods of Sampling Bituminous Materials (Serial Designation: D 140 - 23 T) of the American Society for Testing Materials.[4]

II. PROPERTIES.

Properties. 4. The coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water....................................0.0 per cent
(*b*) Specific gravity at 25°/25° C. (77°/77° F.)....1.24 to 1.34
(*c*) Softening Point[5] (Cube-in-Water Method).............
.... 110 to 140°F. (43.3 to 60.0° C.)

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Specifications are now in course of preparation for low-carbon coal-tar pitch for use in damp-proofing and waterproofing below and above ground level, respectively.

[3] Such coal-tar pitch is not intended to be heated above 300° F. (148.8° C.) during its application.

[4] See p. 759.

[5] The softening point (Cube-in-Water Method) specified should have a range of not over 10° F. within the limits given in Section 4 (*c*).

(*d*) Distillation Test:

Total distillate, by weight, 0.0 to 300° C.
(32 to 572° F.) . . . . not more than 12.0 per cent
Residue, by weight . . . . not less than 88.0 "

(*e*) Specific gravity at 25°/25° C. (77°/77° F.) of total distillate to 300° C. (572° F.) . . . . not less than 1.03

(*f*) Ductility at 25° C. (77° F.) . . . . not less than 50 cm.

(*g*) Insoluble in carbon disulfide . . . . 20 to 35 per cent

III. METHODS OF TESTING.

Methods of Testing.

5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T).[1]

(*b*) *Specific Gravity:* Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (Serial Designation: D 70 – 20 T).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[3]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20).[3]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T).[4]

(*f*) *Insoluble in Carbon Disulfide:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[5]

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[1] See p. 694.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 764 (1920).

[3] 1921 Book of A.S.T.M. Standards.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[5] See p. 751.

TENTATIVE SPECIFICATIONS

FOR

HIGH-CARBON COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING ABOVE GROUND LEVEL[1]

Serial Designation: D 145 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923

Scope. 1. These specifications cover high-carbon coal-tar pitch[2] suitable for use as a mopping-coat in damp-proofing, or as a plying-cement in the construction of a membrane system of waterproofing above ground level, when not exposed to a temperature exceeding 100° F. (37.7° C.).[3]

2. The grade of high-carbon coal-tar pitch covered in these specifications is suitable for damp-proofing and waterproofing railroad bridges, tanks, retaining walls, embankments, culverts, dams, conduits, etc.

I. SAMPLING.

Sampling. 3. The sampling shall be performed in accordance with the Tentative Methods of Sampling Bituminous Materials (Serial Designation: D 140 – 23 T) of the American Society for Testing Materials.[4]

II. PROPERTIES.

Properties. 4. The coal-tar pitch shall be homogeneous and shall meet the following requirements:

(*a*) Water	0.0 per cent
(*b*) Specific gravity at 25°/25° C. (77.° /77° F.)	1.25 to 1.35
(*c*) Softening Point[5] (Cube-in-Water Method)	130 to 155° F. (54.4 to 68.3° C.)

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] Specifications are now in course of preparation for low-carbon coal-tar pitch for use in damp-proofing and waterproofing below and above ground level, respectively.

[3] Such coal-tar pitch is not intended to be heated above 350° F. (176.6° C.) during its application.

[4] See p. 759.

[5] The softening point (Cube-in-Water Method) should have a range of not over 10° F. within the limits given in Section 4 (*c*).

(*d*) Distillation Test:

Total distillate, by weight, 0 to 300° C.
(32 to 572° F.)......................not more than 10.0 per cent
Residue, by weight....................not less than 90.0 "

(*e*) Specific gravity at 25°/25° C. (77°/77° F.)
of total distillate to 300° C. (572° F.)..not less than 1.03
(*f*) Ductility at 25° C. (77° F.) .... not less than 15 cm.
(*g*) Insoluble in carbon disulfide..............22 to 37 per cent

III. METHODS OF TESTING.

Methods of Testing. 5. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T).[1]

(*b*) *Specific Gravity:* Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (Serial Designation: D 70 – 20 T).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[3]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20).[3]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 22 T).[4]

(*f*) *Insoluble in Carbon Disulfide:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 23 T).[5]

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[1] See p. 694.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 764 (1920).

[3] 1921 Book of A.S.T.M. Standards.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922).

[5] See p. 751.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT MASTIC FOR USE IN WATERPROOFING[1]

Serial Designation: D 169 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Scope. 1. (*a*) These specifications cover the materials for asphalt mastic suitable for use in waterproofing, consisting of mastic cake, asphalt cement and mineral aggregate.

(*b*) The grade of asphalt mastic covered by these specifications is suitable for waterproofing bridges, floors, reservoirs, subways, etc.

Properties. 2. Asphalt mastic is a mixture of mastic cake, asphalt cement and mineral aggregate, which at a temperature of approximately 400° F. is sufficiently plastic to be poured into place and compressed with a wooden trowel or equivalent tool into a compact mass.

As used for strictly waterproofing purposes the mastic cake, asphalt cement and mineral aggregate are combined under heat and manual stirring in substantially the following proportions by weight:

Mastic Cake	48 per cent
Asphalt Cement	5 per cent
Mineral Aggregate	47 per cent

Mastic Cake. 3. (*a*) The mastic cake shall conform to the following requirements:

Weight per cake	not more than 75 lb.
Soluble in pure benzol	14 to 18 per cent by weight
Insoluble in pure benzol	82 to 86 per cent by weight

(*b*) The matter soluble in pure benzol shall be asphalt cement, which after recovery from the mastic cake shall conform to the requirements of the Tentative Specifications for Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements (Serial Designation: D 163 - 23 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] See p. 721.

(*c*) The matter insoluble in pure benzol shall be granular mineral matter which after recovery from the mastic cake shall conform to the following requirements as to grading:

Passing 200-mesh sieve	not less than	25 per cent
Passing 10-mesh sieve, retained on 50-mesh sieve	not more than	25 per cent
Retained on 10-mesh sieve	not more than	1 per cent

Asphalt Cement.

4. The asphalt cement shall conform to the requirements of the Tentative Specifications for Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements (Serial Designation: D 163 – 23 T) of the American Society for Testing Materials.[1]

Mineral Aggregate.

5. The mineral aggregate shall be gravel or crushed stone, and sand conforming to the following requirements as to grading:

Passing 200-mesh sieve	none	
Passing 50-mesh sieve, retained on 200-mesh sieve	not more than	25 per cent
Passing 10-mesh sieve, retained on 50-mesh sieve	not less than	25 per cent
Passing 4-mesh sieve, retained on 10-mesh sieve	not less than	50 per cent
Retained on 4-mesh sieve	not more than	10 per cent

Methods of Testing.

6. The properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (Serial Designation: D 147 – 23 T) of the American Society for Testing Materials.[2]

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[1] See p. 721.

[2] See p. 805.

TENTATIVE SPECIFICATIONS
FOR
BITUMINOUS GROUT FOR USE IN WATERPROOFING ABOVE GROUND LEVEL[1]

Serial Designation: D 170 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

Scope.

1. (*a*) These specifications cover the materials for bituminous grout suitable for use in waterproofing above ground level, either as a protective covering of membrane systems of waterproofing or for bedding brick or filling the joints or flooding the surface of a brick protective covering.

(*b*) The grade of bituminous grout covered by these specifications is suitable for waterproofing railroad bridges, culverts, subways, etc.

Properties.

2. Bituminous grout is a mixture of substantially 45 parts by weight of bituminous binder and 55 parts by weight of mineral aggregate as coarse as sand, which becomes sufficiently fluid when heated to approximately 400° F. to flow without mechanical manipulation, and which on cooling congeals to a compact mass.

Bituminous Binder.

3. The bituminous binder shall consist of either asphalt binder or coal-tar pitch as follows:

(*a*) The asphalt binder shall conform to the requirements of the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level (Serial Designation: D 144 – 23 T) of the American Society for Testing Materials.[2]

(*b*) The coal-tar pitch shall conform to the requirements of the Tentative Specifications for High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (Serial Designation: D 42 – 23 T) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] See p. 775.

[3] See p. 777.

Mineral Aggregate. 4. The mineral aggregate shall consist of silicious sand, all of which will pass a 20-mesh sieve, and not more than 5 per cent of which will pass a 200-mesh sieve.

Methods of Testing. 5. The properties enumerated in Sections 2 and 4 shall be determined in accordance with the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (Serial Designation: D 147 - 23 T) of the American Society for Testing Materials.[1]

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[1] See p. 805.

TENTATIVE SPECIFICATIONS
FOR
BITUMINOUS GROUT FOR USE IN WATERPROOFING BELOW GROUND LEVEL[1]

Serial Designation: D 171 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Scope.

1. (*a*) These specifications cover the materials for bituminous grout suitable for use in waterproofing below ground level, either as a protective covering of membrane systems of waterproofing or for bedding brick or filling the joints or flooding the surface of a brick protective covering.

(*b*) The grade of bituminous grout covered by these specifications is suitable for waterproofing tunnels, subways, etc.

Properties.

2. Bituminous grout is a mixture of substantially 45 parts by weight of bituminous binder and 55 parts by weight of mineral aggregate as coarse as sand, which becomes sufficiently fluid when heated to approximately 300° F. to flow without mechanical manipulation, and which on cooling congeals to a compact mass.

Bituminous Binder.

3. The bituminous binder shall consist of either asphalt binder or coal-tar pitch as follows:

(*a*) The asphalt binder shall conform to the requirements of the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level (Serial Designation: D 40 – 23 T) of the American Society for Testing Materials.[2]

(*b*) The coal-tar pitch shall conform to the requirements of the Tentative Specifications for High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level (Serial Designation: D 42 – 23 T) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

[2] See p. 773.

[3] See p. 777.

Mineral Aggregate. 4. The mineral aggregate shall consist of silicious sand, all of which will pass a 20-mesh sieve, and not more than 5 per cent of which will pass a 200-mesh sieve.

Methods of Testing. 5. The properties enumerated in Sections 2 and 4 shall be determined in accordance with the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (Serial Designation: D 147 – 23 T) of the American Society for Testing Materials.[1]

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[1] See p. 805.

TENTATIVE SPECIFICATIONS
FOR
FELTED FABRICS SATURATED WITH BITUMINOUS SUBSTANCES FOR USE IN WATERPROOFING[1]

Serial Designation: D 172 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

I. MANUFACTURE

Scope. 1. These specifications cover bituminized felted fabrics, composed of rag-felt saturated, but not coated, with either asphalt or coal-tar pitch, as specified by the purchaser, for use in the membrane system of waterproofing.

Manufacture. 2. In the process of manufacture, the dry felt shall be thoroughly and uniformly impregnated with an asphaltic or coal-tar pitch saturant at a temperature and speed which will not injure the fabric. This shall be accomplished by passing the dry felt through the saturant, and then calendering it in the presence of heat, whereupon it shall be cooled and wound into rolls.

II. PHYSICAL PROPERTIES

Fabricated Bituminized Felt. 3. The fabricated bituminized felt shall conform to the following requirements:

(*a*) The width shall be 32 or 36 in. with a permissible variation of 1 per cent.

(*b*) The gross weight per roll shall fall within the range of 50 to 80 lb.

(*c*) The wrapping and packing material shall not weigh more than 0.5 lb. per roll.

(*d*) The average net weight per 100 sq. ft. shall be 14 lb., with a permissible variation of 8 per cent.

(*e*) The detached comminuted surfacing per 100 sq. ft. shall not weigh more than 1 lb.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

(*f*) The maximum variation from the average thickness after removal of the detached surfacing shall not exceed 15 per cent.

(*g*) The moisture content based on the net weight shall not be more than 1 per cent.

(*h*) The average strength at 70° F. (21.1° C.) with the fiber grain (that is measured lengthwise of the roll) shall not be less than 25 lb.

(*i*) The average strength at 70° F. (21.1° C.) across the fiber grain (that is measured crosswise of the roll) shall not be less than 15 lb.

(*j*) The pliability at 77° F. (25° C.) shall be greater than 8.

(*k*) The average loss on heating (exclusive of moisture) shall not be more than 4 per cent with asphalt-saturated felt.

(*l*) The weight of the saturant contained in the fabricated material shall not be less than 1.4 times the weight of the moisture-free felt in the same area.

Desaturated Rag-Felt.

4. The desaturated rag-felt shall conform to the following requirements:

(*a*) The average "number" (expressed on the basis of pounds per 480 sq. ft.) shall be 28, equivalent to 5.84 lb. per 100 sq. ft., with a permissible variation of 10 per cent.

(*b*) The ash, based on the dry weight of the felt, shall not be more than 8 per cent.

(*c*) The composition of the felt based on a microscopic count of the fibers shall be as follows:

Cotton and wool fibers	not less than	75 per cent
Jute and manila fibers	not more than	15 per cent
Mechanical wood, etc., fibers	not more than	5 per cent
Chemical wood fibers	not more than	5 per cent

III. METHODS OF SAMPLING AND TESTING

Methods of Testing.

5. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing (Serial Designation: D 146 – 23 T) of the American Society for Testing Materials[1].

IV. WORKMANSHIP AND FINISH

Workmanship and Finish.

6. The finished material shall be free from visible external defects such as holes, ragged or untrue edges, breaks, rents, cracks or indentations.

7. The roll shall be capable of being unrolled easily at atmospheric temperatures above 50° F. (10° C.) without sticking together in such a manner as to injure the fabric.

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[1] See p. 796.

8. The surface of the fabric shall not be coated or covered with talc, or other substance which would tend to interfere with the adhesion between the fabric and the plying cement. The use of silica or wood flour will be permitted.

9. The surface shall be uniformly smooth and shall be reasonably free from the following:

(*a*) Lumps of underbeaten stock (*i. e.*, stock which has not been entirely beaten or shredded into fiber in the process of manufacturing the felt);

(*b*) Foreign substances (*i. e.*, fragments of stone, metal, leather, straw, wood, etc.);

(*c*) Areas or patches of unabsorbed saturant;

(*d*) Superficial "dry" spots.

10. The felt shall be thoroughly and uniformly impregnated and shall show no unsaturated spots at any point, upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

V. PACKING

Packing.

11. The rolls of saturated felt need not be wound on cores, but they shall be securely wrapped in a substantial grade of paper of the same width as the fabric. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the roll need not be covered.

VI. INSPECTION AND REJECTION

Inspection.

12. Inspection may be made either at the point of shipment or at the point of delivery. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection.

13. Any rejection based upon failure to conform to the requirements of these specifications shall be reported within ten days from the taking of the samples. The notice of rejection shall contain a specific statement of the respects in which the material has failed to meet the requirements of these specifications.

Rehearing.

14. (*a*) Either of the contracting parties may make claim for a retest within five days from the date of rejection. The expense of the test shall be borne by the party demanding such retest.

(*b*) Should the contracting parties be unable to reach a mutually satisfactory agreement, samples of the material shall be taken by a referee laboratory for test and the results of this referee test shall be binding on both parties.

TENTATIVE SPECIFICATIONS
FOR
WOVEN COTTON FABRICS SATURATED WITH BITUMINOUS SUBSTANCES FOR USE IN WATERPROOFING[1]

Serial Designation: D 173 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

I. MANUFACTURE

Scope.

1. These specifications cover bituminized cotton fabric, composed of woven cotton cloth waterproofed with either asphalt or coal-tar pitch, as specified by the purchaser, for use in the membrane system of waterproofing.

Manufacture.

2. In the process of manufacture, the dry cotton fabric shall be thoroughly and uniformly waterproofed with an asphaltic or coal-tar pitch saturant, at a temperature and speed which will not injure the fabric. This shall be accomplished by passing the fabric through the saturant and then calendering it in the presence of heat, whereupon it shall be cooled and wound into rolls.

II. PHYSICAL PROPERTIES

Fabricated Bituminized Fabric.

3. The fabricated bituminized cotton fabric shall conform to the following requirements:

(*a*) The width shall be not less than 30 in. nor more than 38 in.

(*b*) The gross weight per roll shall fall within the range of 35 to 80 lb.

(*c*) The wrapping material and mandril shall not weigh more than 2.5 lb. per roll.

(*d*) The average net weight per square yard shall not be less than 11 oz.

(*e*) The detached comminuted surfacing per 100 sq. ft. shall not weigh more than 1 lb.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

(*f*) The moisture content based on the net weight shall not be more than 1 per cent.

(*g*) The average strength at 70° F. (21.1° C.) measured lengthwise of the roll (that is, in the direction of the warp) shall not be less than 50 lb.[1]

(*h*) The average strength at 70° F. (21.1° C.) measured crosswise of the roll (that is, in the direction of the filling) shall not be less than 40 lb.[1]

(*i*) The pliability at 32° F. (0° C.) shall not be less than 10.

(*j*) The average loss on heating (exclusive of moisture) shall not be more than 4 per cent with asphalt-saturated fabrics.

(*k*) The weight of the saturant contained in the fabricated material shall not be less than twice the weight of the moisture-free fabric in the same area.

Desaturated Fabric.

4. The desaturated woven cotton fabric shall conform to the following requirements:

(*a*) The average dry weight shall not be less than 3½ oz. per sq. yd.

(*b*) The ash based on the dry weight of the fabric shall not be more than 1 per cent.

(*c*) The fabric shall be composed of not less than 100 per cent of cotton fibers.

(*d*) The thread count per inch both in the direction of the warp and in the direction of the filling shall not be more than 36.

III. METHODS OF SAMPLING AND TESTING

Methods of Testing.

5. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing (Serial Designation: D 146 - 23 T) of the American Society for Testing Materials.[2]

IV. WORKMANSHIP AND FINISH

Workmanship and Finish.

6. The finished material shall be free from visible external defects such as ragged or untrue edges, breaks, rents or cracks.

7. The meshes of the fabric shall not be completely closed or sealed by the process of saturation, but there shall be sufficient porosity maintained to allow successive moppings of the plying cement to seep through.

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[1] The committee recognizes the advisability of including a requirement relative to the percentage elongation before rupture, but in the absence of any reliable method of test, such requirement cannot be stated at the present time.

[2] See p. 796.

8. The selvage shall not measure over $\frac{3}{16}$ in.

9. The roll shall be capable of being unrolled easily at atmospheric temperatures above 50° F. (10° C.) without sticking together in such a manner as to injure the fabric.

10. The surface of the fabric shall not be coated or covered with talc or other substance which would tend to interfere with the adhesion between the fabric and the plying cement. The use of silica or wood flour will be permitted.

11. The surface shall be uniformly smooth and free from irregularities, folds or knots.

V. PACKING

12. The rolls of treated cotton fabric shall be wound on 2 by 2-in. wooden mandrils extending 2 to 4 in. beyond the ends of the rolls. They shall be securely tied or wrapped in a manner which will prevent unrolling in transit.

VI. INSPECTION AND REJECTION

Inspection. 13. Inspection may be made either at the point of shipment or at the point of delivery. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 14. Any rejection of material based upon failure to conform to the requirements of these specifications shall be reported within ten days from the taking of the samples. The notice of rejection shall contain a specific statement of the respects in which the material has failed to meet the requirements of these specifications.

Rehearing. 15. (*a*) Either of the contracting parties may make claim for a retest within five days from the date of rejection. The expense of the retest shall be borne by the party demanding such retest.

(*b*) Should the contracting parties be unable to reach a mutually satisfactory agreement, samples of the material shall be taken by a referee laboratory for test and the results of this referee test shall be binding on both parties.

TENTATIVE SPECIFICATIONS
FOR
BURLAP SATURATED WITH BITUMINOUS SUBSTANCES FOR USE IN WATERPROOFING[1]

Serial Designation: D 174 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

I. MANUFACTURE

Scope.

1. These specifications cover bituminized jute fabric, composed of burlap waterproofed with either asphalt or coal-tar pitch, as specified by the purchaser, for use in the membrane system of waterproofing.

Manufacture.

2. In the process of manufacture, the dry burlap shall be thoroughly and uniformly waterproofed with an asphaltic or coal-tar pitch saturant at a temperature and speed which will not injure the fabric. This shall be accomplished by passing the fabric through the saturant and then calendering it in the presence of heat, whereupon it shall be cooled and wound into rolls.

II. PHYSICAL PROPERTIES

Fabricated Bituminized Burlap.

3. The fabricated bituminized burlap shall conform to the following requirements:

(*a*) The width shall be not less than 30 in. nor more than 38 in.

(*b*) The gross weight per roll shall fall within the range of 35 to 80 lb.

(*c*) The wrapping material and mandril shall not weigh more than 2.5 lb. per roll.

(*d*) The average net weight per square yard shall not be less than 20 oz.

(*e*) The detached comminuted surfacing per 100 sq. ft. shall not weigh more than 1 lb.

(*f*) The moisture content based on the net weight shall not be more than 1 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

(*g*) The average strength at 70° F. (21.1° C.) measured lengthwise of the roll (that is, in the direction of the warp) shall not be less than 70 lb.[1]

(*h*) The average strength at 70° F. (21.1° C.) measured crosswise of the roll (that is, in the direction of the filling) shall not be less than 50 lb.[1]

(*i*) The pliability at 32° F. (0° C.) shall not be less than 10.

(*j*) The average loss on heating (exclusive of moisture) shall not be more than 4 per cent with asphalt-saturated fabrics.

(*k*) The weight of the saturant contained in the fabricated material shall not be less than twice the weight of the moisture-free fabric in the same area.

Desaturated Burlap.

4. The desaturated burlap shall conform to the following requirements:

(*a*) The average dry weight shall not be less than 7½ oz. per sq. yd.

(*b*) The ash based on the dry weight of the fabric shall not be more than 3 per cent.

(*c*) The fabric shall be composed of not less than 100 per cent jute and manila fibers.

III. METHODS OF SAMPLING AND TESTING

Methods of Testing.

5. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing (Serial Designation: D 146 - 23 T) of the American Society for Testing Materials.[2]

IV. WORKMANSHIP AND FINISH

Workmanship and Finish.

6. The finished material shall be free from visible external defects such as ragged or untrue edges, breaks, rents or cracks.

7. The meshes of the fabric shall not be completely closed or sealed by the process of saturation, but there shall be sufficient porosity maintained to allow successive moppings of the plying cement to seep through.

8. The selvage shall not measure over $\frac{3}{16}$ in.

9. The roll shall be capable of being unrolled easily at atmospheric temperatures above 50° F. (10° C.) without sticking together in such a manner as to injure the fabric.

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[1] The committee recognizes the advisability of including a requirement relative to the percentage elongation before rupture, but in the absence of any reliable method of test, such requirement cannot be stated at the present time.

[2] See p. 796.

10. The surface of the fabric shall not be coated or covered with talc or other substances which would tend to interfere with the adhesion between the fabric and the plying cement. The use of silica or wood flour will be permitted.

11. The surface shall be uniformly smooth and free from irregularities, folds or knots.

V. PACKING

Packing.

12. The rolls of treated burlap shall be wound on wooden 2 by 2-in. mandrils extending 2 to 4 in. beyond the ends of the roll. They shall be securely tied or wrapped in a manner which will prevent unrolling in transit.

VI. INSPECTION AND REJECTION

Inspection.

13. Inspection may be made either at the point of shipment or at the point of delivery. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection.

14. Any rejection of material based upon failure to conform to the requirements of these specifications shall be reported within ten days from the taking of the samples. The notice of rejection shall contain a specific statement of the respects in which the material has failed to meet the requirements of these specifications.

Rehearing.

15. (*a*) Either of the contracting parties may make claim for a retest within five days from the date of rejection. The expense of the retest shall be borne by the party demanding such retest.

(*b*) Should the contracting parties be unable to reach a mutually satisfactory agreement, samples of the material shall be taken by a referee laboratory for test and the results of this referee test shall be binding on both parties.

TENTATIVE METHODS OF TESTING FELTED AND WOVEN FABRICS SATURATED WITH BITUMINOUS SUBSTANCES FOR USE IN WATERPROOFING[1]

Serial Designation: D 146 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923

Scope. 1. These methods cover the examination of felted or woven fabrics saturated (but not coated) with asphalt or coal-tar products, for use in the "membrane" system of waterproofing.

I. SAMPLING.

Sampling. 2. From each shipment or portion thereof representing a product of the same kind, class and weight, a number of rolls shall be selected at random, equivalent to the cube root of the total number of rolls in the lot. If the cube root, as calculated, proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

Packages in Shipment.	Number of Packages Selected.	Packages in Shipment.	Number of Packages Selected.
2 to 8	2	1332 to 1728	12
9 to 27	3	1729 to 2197	13
28 to 64	4	2198 to 2744	14
65 to 125	5	2745 to 3375	15
126 to 216	6	3376 to 4096	16
217 to 343	7	4097 to 4913	17
344 to 512	8	4914 to 5832	18
513 to 729	9	5833 to 6859	19
730 to 1000	10	6860 to 8000	20
1001 to 1331	11	8001 to 9261	21

II. EXAMINATION OF FINISHED FABRIC.

Width. 3. The width of each roll taken shall be measured to the nearest $\frac{1}{32}$ in. The minimum, maximum and average width so obtained shall be reported.

Gross Weight per Roll. 4. Each roll taken shall be weighed intact to the nearest $\frac{1}{4}$ lb. and the minimum, maximum and average gross weight shall be reported.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

Wrapping and Packing Materials.

5. Each roll sampled shall be stripped. All the wrappers and packing material shall be weighed together to the nearest $\frac{1}{4}$ lb. and the average weight shall be reported. Each roll should be temporarily fastened with a piece of light string and handled carefully, so as not to disturb any detached surfacing material.

Net Weight per Roll.

6. The minimum, maximum and average net weight per roll shall be calculated by subtracting the average weight of the wrapping and packing material as determined in Section 5 from the average gross weight as determined in Section 4.

Weight per Unit Area.

7. Each roll sampled shall be laid flat, the first convolution or two carefully unwound, and with a knife and straight edge the sheet shall be cleanly cut across at right angles to the edges. A section measuring 30 in. in the direction of the roll's length shall be removed. If the material is surfaced with sand or other fine material any detached particles belonging to each 30-in. section should be retained. The width of each section shall be measured to the nearest $\frac{1}{32}$ in. Each section, together with any detached surfacing, shall be weighed to the nearest gram. The weight in pounds per 100 sq. ft. or the weight in ounces per sq. yd. shall be calculated from the formulas:

$$\text{Pounds per 100 sq. ft.} = 1.0582 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

$$\text{Ounces per sq. yd.} = 1.5238 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

From the results obtained for each roll sampled, the minimum, maximum, and average weight shall be calculated.

NOTE.—As a referee method or in case any dispute arises regarding the weight "per unit area," the method described in Section 8 shall be followed. From the net weight of each roll determined as in Section 6, the weight per unit area may be calculated as a check.

Area per Roll.

8. The average area per roll in square feet shall be calculated by dividing the average net weight per roll, as determined in Section 6, by the average weight in pounds per 100 sq. ft. as determined in Section 7, and multiplying by 100.

NOTE.—As a referee method or in case any dispute arises regarding the "area per roll" as calculated, each roll sampled shall be unwound and the total length measured within $\frac{1}{4}$ in. with a steel tape. From the width of each roll, as determined in Section 3, the "area per roll" may be accurately calculated as a check and the minimum, maximum and average for the shipment calculated.

Detached Comminuted Surfacing.

9. If the material is surfaced with sand or other finely comminuted material, the surfacing shall be swept with a moderately stiff brush from all the 30-in. sections taken. All the material thus removed shall be caught and weighed to the nearest ounce. From the aggregate areas of all the sections taken, the average weight of detached comminuted surfacing shall be calculated in pounds per 100 sq. ft.

Thickness. 10. The thickness of each specimen shall be measured at 10 equally spaced points, 1 in. from a cut edge, with a micrometer gage having flat bearing surfaces at both contact points of not less than $\frac{1}{2}$ in. in diameter and preferably of the spring-and-dial type. The readings for each roll sampled shall be averaged and the minimum, maximum and average thickness calculated to the nearest 0.001 in.

Moisture. 11. From each specimen, 2-in. strips shall be cut as shown at *A-1* and *A-2* in Fig. 1. The 2-in. strips shall be cut into 1-in. squares. About 50 g., selected at random, shall be accurately weighed and distilled with 100 cc. of a coal-tar distillate of which 5 to 10 per cent boils below 100° C. (212° F.) and of which at least 90 per cent distills up to 180° C. (356° F.) in an apparatus of the form and under the conditions prescribed in the Tentative Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95 – 23 T) of the American Society for Testing Materials.[1] The flask containing the solvent and sample shall be heated in a paraffin bath at a temperature of 302 to 338° F. (150 to 170° C.) until no further water passes over. The distillate shall be allowed to stand in the graduated receiver until the water separates, whereupon the volume of water shall be measured and its weight calculated. From this, the

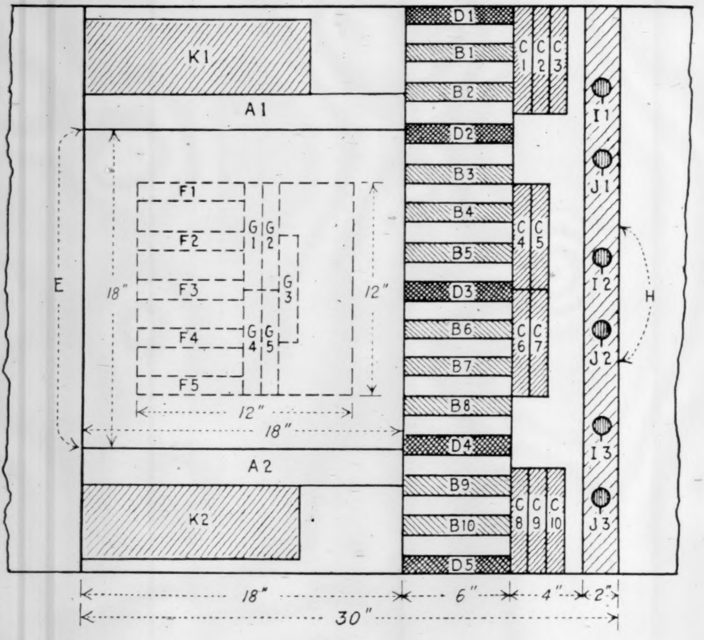

FIG. 1

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[1] See p. 694.

average percentage of moisture in the fabric, as received, shall be calculated.

Strength. 12. (*a*) *Felted Fabrics.*—With a photographic trimmer having a stop attached exactly 1 in. behind the blade, ten strips shall be cut with the fiber grain, as shown at *B-1* to *B-10* (Fig. 1) and ten strips across the fiber grain as shown at *C-1* to *C-10*. Each strip should measure 6 in. and have parallel sides 1 in. apart (within $\frac{1}{32}$ in.) with the edges cut straight and clean. Both sets of strips shall be tested at 70° F. (21.1° C.), using a tension testing machine such as the Scott Strength Tester (Type F, 100 lb. capacity), the Perkins Strip Tester, or equal, in which the clamps are attached to swivels free to move in any direction. The test strips shall be gripped $1\frac{1}{2}$ in. on each end, leaving approximately 3 in. between the clamps. The tension shall be increased at a uniform speed of 3 lb. per second, using a metronome. If any strip breaks nearer than $\frac{1}{2}$ in. to either clamp, the reading shall be disregarded, and an additional strip shall be tested in its place. The ten readings, with and across the grain, respectively, shall be averaged for each roll sampled. From these results the average strength with and across the fiber grain, respectively, of the fabric as supplied, shall be calculated.

(*b*) *Woven Fabrics.*—Woven fabrics shall be tested at 70° F. (21.1° C.) in accordance with the "grab test No. 2" as described in Section 12 (*b*) of the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials,[1] with the exception that the distance between the jaws shall be 3 in.

NOTE.—As a referee method, or in case any dispute arises regarding the strength, the test shall be repeated, with the exception that the fabric before testing shall be exposed at least two hours in an atmosphere of 65 per cent relative humidity at 70° F. (21.1° C.).

Pliability. 13. With the trimmer described in Section 12 (*a*), five 6-in. strips shall be cut with the fiber grain, as shown at *D-1* to *D-5* (Fig. 1) and immersed in water at 77° F. (25° C.) for from 10 to 15 minutes. These strips shall be bent through 180 deg. at a uniform speed, in exactly 2 seconds, around a mandril, the diameter of which shall be as follows: The first, around a mandril 25 mm. in diameter; the second, around a mandril 20 mm. in diameter; the third, around a mandril 15 mm. in diameter; the fourth, around a mandril 10 mm. in diameter, and the fifth, around a mandril 5 mm. in diameter. The test may also be made at 32° F. (0° C.). The pliability shall be expressed numerically from 1 to 10 as follows:

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[1] 1921 Book of A.S.T.M. Standards.

(1) Cracks entirely through the sheet on the 25-mm. mandril.
(2) Cracks part way through the sheet on the 25-mm. mandril.
(3) Cracks on the 25-mm. mandril.
(4) Cracks on the 20-mm. mandril.
(5) Cracks on the 15-mm. mandril.
(6) Cracks on the 10-mm. mandril.
(7) Cracks on the 5-mm. mandril.
(8) Cracks when bent through 180 deg. flat on itself.
(9) May be bent through 180 deg. flat on itself in one direction without cracking, but will crack when bent through 360 deg. in the opposite direction.
(10) May be bent through 180 deg. flat on itself in one direction and then through 360 deg. flat on itself in the opposite direction without cracking.

The readings for each roll shall be averaged separately, and from these results the minimum, maximum and average pliability of the felt shall be calculated.

Water Absorbed.

14. (*a*) A section 18 in. square (as shown at *E*, Fig. 1) shall be cut from each specimen, weighed, and completely immersed in distilled water at 77° F. (25° C.) for 24 hours. The specimen shall then be removed and dried superficially by pressing lightly between two towels. As the moisture enters through the edges of the sheet more rapidly than through the surfaces, each specimen shall be trimmed to exactly 12 in. square, representing four-ninths of the original area, and reweighed rapidly. The increase in weight shall be calculated on the basis of the original test specimen by multiplying by $2\frac{1}{4}$. The percentage increase in weight represents the water absorption. The minimum, maximum and average for the shipment shall be calculated.

(*b*) Five strips shall be cut with the fiber grain as shown at *F 1* to *F 5* (Fig. 1); five other strips shall be cut across the fiber grain as shown at *G 1* to *G 5* (Fig. 1) and the strength shall be redetermined as in Section 12. The decrease in strength in percentage shall be calculated after the specimen has been subjected to water.

Loss on Heating.

15. From each specimen, 12 by 6-in. strips shall be cut at *K-1* and *K-2* in Fig. 1, care bring taken not to disturb any of the detached surfacing. Each strip shall be weighed and suspended in the center of an air oven maintained at 221° F. (105° C.) ± 5° F. (3° C.) with a thin wire fastened through holes punctured near one edge. The thermometer shall be inserted in the oven to such a depth that its bulb will be in line with the center of the specimens. The strips shall be kept in the oven for exactly 5 hours, then cooled and removed carefully, and each specimen weighed. The average loss shall be

calculated as a percentage and the average percentage of moisture (ascertained in Section 11) deducted. The final figure shall represent the average loss on heating, exclusive of moisture.

III. DESATURATING THE FABRIC.

Desaturated Fabric.

16. From each roll sampled, a 2-in. strip (within $\frac{1}{32}$ in.) shall be cut across the specimen as shown at *H* (Fig. 1). Each strip shall be extracted with c. p. benzol in an extractor described in Section 4 of the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (Serial Designation: D 147 - 23 T) of the American Society for Testing Materials,[1] the extraction being continued for several hours after the drippings have become colorless. The desaturated fabric shall be removed and heated in a ventilated oven at 225° F. (107.1° C.), cooled in a desiccator, any adhering comminuted surfacing being brushed off and retained, and weighed as rapidly as possible. The heating shall be repeated until the weight of the fabric remains constant as determined by two consecutive weighings taken not less than ten minutes apart which shall show a further loss of not more than 0.1 per cent. This will give the weight of the fabric in the moisture-free state. Where a coal-tar pitch saturant has been used, the moisture-free weight of the desaturated fabric shall be corrected for the carbonaceous matter retained mechanically in its interstices, by means of the method described in Section 17.

Retained Carbonaceous Matter.

17. The following colorimetric method shall be used to ascertain the carbonaceous matter derived from a coal-tar pitch saturant and retained by the desaturated fabric:

(*a*) About 15 g. of an unsaturated fabric of the same general character as the one under examination, shall be macerated by boiling in water, disintegrating with a rotary egg-beater and picking the fibers apart with needles. The fibers shall be filtered through fine cloth and dried at a temperature of 225° F. (107.1° C.) to constant weight. One gram of the fibers shall be accurately weighed into a flask and diluted to exactly 100 cc. with distilled water at room temperature. About 50 g. of glass beads shall be added and the contents of the flask shaken vigorously until the fibers are reduced to a homogeneous pulp in uniform suspension.

(*b*) A distilled coal-tar, having approximately 10 to 25 per cent of insoluble carbonaceous matter, shall be procured and the carbonaceous matter extracted with benzol until it is free from soluble matter; then dried at a temperature of 225° F. (107.1° C.) to constant weight. One gram of the purified carbonaceous matter shall be accurately weighed and diluted to exactly 100 cc. at room temperature with a starch solution of a consistency sufficient to carry the carbonaceous matter into temporary suspension. (A 12.5-per-cent solution is recommended.)

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[1] See p. 805.

(*c*) The liquid carrying the fibers, obtained as described in Paragraph (*a*), shall be titrated with the suspension of carbonaceous matter, obtained as described in Paragraph (*b*), and from time to time a field prepared from a drop of the well agitated mixture shall be examined under a microscope at 100 diameters magnification until the color exactly matches a field prepared from the desaturated fabric under examination (obtained as described in Section 16), when both are viewed side by side under parallel conditions. The end-point is fairly sharply defined. The burette reading gives directly the percentage of carbonaceous matter adhering to the moisture-free fabric under examination.

(*d*) The weight of moisture-free fabric ascertained in Section 16 shall be corrected by deducting the weight of adhering carbonaceous matter.

Total Comminuted Surfacing.

18. The total comminuted surfacing plus any filler present in the bituminous saturant represents the sum of the detached comminuted surfacing (Section 9), the amount brushed off from the surface of the desaturated fabric (Section 16), plus the amount recovered upon evaporating and igniting the bituminous extract obtained in accordance with Section 16.

Bituminous Saturant.

19. The weight of bituminous saturant represents the difference between the weight of the original fabric (Section 7), and the sum of the weights of the moisture-free desaturated fabric (Sections 16 and 17), plus moisture (Section 11), plus the total comminuted surfacing and filler present (Section 18).

IV. EXAMINATION OF THE EXTRACTED FABRIC.

(*A*) *Woven Fabrics.*

Weight.

20. Woven fabrics shall be tested for weight and number of threads per in. in accordance with Sections 6 to 11, inclusive, of the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

(*B*) *Felted Fabrics.*

Weight.

21. The weight in pounds per 480 sq. ft. of the desaturated felt (corrected for any carbonaceous matter present) for each specimen examined, shall be calculated separately from the formulas:

$$\text{“Number”} = \frac{\text{Weight of specimen in grams}}{\text{Area of specimen in square centimeters}} \times 983$$

or

$$\text{“Number”} = \frac{\text{Weight of specimen in grams}}{\text{Area of specimen in square inches}} \times 152$$

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[1] 1921 Book of A.S.T.M. Standards.

This represents the "number" of the moisture-free felt on the felt makers' scale. The minimum, maximum and average "number" of the felt in its moisture-free state shall be calculated. This may be corrected to the condition in which it actually existed in the material under examination, by adding thereto the percentage of moisture as determined in Section 11.

Ash.

22. A representative sample shall be secured by cutting from each strip of desaturated felt a piece about $\frac{1}{2}$ in. in diameter as shown at *I-1*, *I-2*, and *I-3* (Fig. 1). About 25 g. selected at random from all the specimens sampled in this manner shall be accurately weighed, and incinerated in a weighed porcelain or quartz crucible either over an open flame or in a muffle, until all the carbon is consumed. A few drops of ammonium carbonate solution shall be added, the sample ignited gently, and weighed. The percentage of ash shall be calculated on the basis of the moisture-free felt.

NOTE.—As a referee method, or in case greater accuracy is desired, the three portions taken from each specimen roll shall be weighed and ignited separately. The minimum, maximum and average of ash present shall be calculated on the basis of the moisture-free felt.

Fibers Present.

23. (*a*) A representative sample shall be secured by cutting from each strip of desaturated felt a piece about $\frac{1}{2}$ in. in diameter as shown at *J-1*, *J-2*, and *J-3* (Fig. 1). The pieces shall be placed in a small beaker, boiled with water and macerated until the fibers are well separated and reduced to a pulp. They shall then be transferred to a stout flask. About 50 g. of glass beads shall be added and the contents of the flask shaken vigorously until the fibers are reduced to a homogeneous mass in a uniform suspension. A small portion of the well-mixed pulp shall be removed with a dropper or pipette and three or four drops shall be rapidly transferred to a microscope slide. Ten such slides shall be prepared, refilling the dropper each time.

(*b*) The drops shall be spread thinly over the microscope slides with a needle so that the fibers will be uniformly distributed and not bunched together. The slides shall then be placed in an air-bath to expel the water, cooled and stained with a drop or two of zinc-chlor-iodide solution.

NOTE—The zinc-chlor-iodide solution may be prepared by dissolving 4 g. of potassium iodide and 0.1 g. of iodine in 12 cc. of water, and then adding 20 g. of zinc chloride and allowing the liquid to stand until all undissolved matter has settled out. This solution must be kept in a dark place and prepared freshly from time to time, as it loses its strength. To test out the stain, a mixture of equal parts of rag filter paper, bleached soda pulp and bleacher sulfite pulp, shall be prepared, and tested as directed. If the stain is of the correct strength, the rag fibers will show a wine-red color, the soda pulp a dark purple color, due to the thicker and more opaque fiber walls, and the sulfite pulp a light purple color due to the thinner fiber walls. If the purple color is more of a violet, then too much iodine is present and more water or zinc chloride should be added. Zinc chloride intensifies the purple color, iodine the wine-red and yellow colors, and water serves to weaken the color that predominates.

(*c*) The stained pulp shall be covered with round or square pieces of thin glass approximately $\frac{1}{2}$ in. in diameter, and the excess of staining solution shall be removed from the edges with a piece of filter paper.

(*d*) The slides shall be examined under a microscope having a magnification of about 100 diameters.

(*e*) The various fibers are colored as follows:

Rag Fibers.—
  Cotton and linen fibers—stained wine-red.
  Wool fibers—unstained by the solution.
  Jute and manila fibers—stained yellowish-brown.

Paper, Wood, Straw, etc., Fibers.—
  Mechanical wood pulp, sawdust, straw, bark, etc.—stained lemon yellow.
  Chemical wood pulp, (sulfite or soda), stained grayish purple to purple.

(*f*) The eye may be trained to the colors and shapes of the various fibers by examining specimens of known composition under similar conditions. In this way the fibers may readily be identified in unknown mixtures by:

(1) The colors to which they are stained.
(2) Their characteristic sizes and shapes.

(*g*) The fibers shall be counted in each field, disregarding any short ends projecting into the field or small fragments interspersed throughout it. Small particles of sizing, clay, or mineral matter should likewise be disregarded.

(*h*) Five fields shall be selected at random on each slide and the fibers counted in each. A total of 50 fields will be thus examined. The aggregate number of each variety of fiber counted in all the fields shall be calculated in percentage.

(*i*) The fibers present shall be reported in percentage *based on their count*, and should be generally accurate to within 5 per cent, depending upon the skill of the operator.

NOTE 1.—As the dimensions and specific gravity of the fibers have not been taken into consideration, the method is obviously inaccurate to this extent. Spence and Krauss[1] have worked out a set of factors for expressing the results into terms of weight, taking into consideration the dimensions and specific gravity of the fibers. This method is recommended, although it is somewhat slow and laborious.

NOTE 2.—As a referee method, or in case greater accuracy is desired, a separate microscope test shall be run on the three portions taken from each specimen roll. The minimum, maximum and average percentage of the various fibers present shall then be calculated.

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[1] *Paper*, Vol. XX, No. 11, p. 11, May 23, 1917.

TENTATIVE METHODS OF TESTING BITUMINOUS MASTICS, GROUTS AND LIKE MIXTURES.[1]

Serial Designation: D 147 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923

I. DEFINITIONS.

Scope.

1. These methods apply to bituminous mastics, grouts and like mixtures, which may be classified and defined as follows:

Bituminous Grout.—A mixture of bituminous material as a binder and sandy mineral matter as an aggregate, which at approximately 300° F. becomes sufficiently fluid to flow into place without mechanical manipulation, and which on cooling congeals to a compact mass.

Asphalt Mastic.—(1) A mixture containing asphaltic material as a binder and graded mineral matter as an aggregate, or (2) pulverized natural bituminous rock (to which bitumen may be added); either of which at approximately 400° F. may be poured into place but which requires trowelling to form it into a compact mass.

Asphalt Mastic Cake.—A mixture containing asphaltic material as a binder and an aggregate consisting of calcareous or siliceous dust, together with sand, cast in the form of blocks or "cakes" and adapted for use in preparing asphalt mastic.

II. PREPARATION OF SAMPLES.

Preparation of Samples.

2. (*a*) Bituminous grouts shall be heated in an oven or on a hot plate in a pan or other suitable container at the lowest possible temperature to prevent overheating and volatilization, and when sufficiently fluid, shall be thoroughly stirred to insure a uniform sample, whereupon 10 to 30 g. shall be taken for analysis.

(*b*) Asphalt mastics or mastic cake shall be warmed on a hot plate or in a hot oven until soft enought to be broken up or stirred so that a representative sample for analysis may be taken. The amount taken for analysis will depend upon the amount of coarse gravel or stone in the mixture. The larger the gravel or stone, the larger will be the sample required for accuracy. The size of samples to be taken shall be as follows: Where all particles pass a 10-mesh sieve, 10 to 30 g.; where 25 per cent of the aggregate is retained on a 10-mesh sieve, 50 g.; where 50 per cent of the aggregate is retanied on a 10-mesh sieve, 100 g.; and where 75 per cent of the aggregate is retained on a 10-mesh sieve, 200 g.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1924, to Mr. Prévost Hubbard, Secretary of Committee D-8 on Waterproofing Materials, 25 W. Forty-third St., New York City.

NOTE.—Where the properties of the extracted bituminous matter are to be determined, 500 g. shall be taken and extracted with pure benzol as described in Sections 4 and 6 and examined as described in Section 7.

III. APPARATUS.

(*A*) *For Analysis of 10 to 30-g. Samples.*

Apparatus, 10 to 30-g. Samples.

3. In cases where a 10 to 30-g. sample is sufficient, the analysis shall be carried out by means of the glass extractor described in Section 8 of the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 - 23 T) of the American Society for Testing Materials.[1]

(*B*) *For Analysis of 50 to 500-g. Samples.*

Apparatus, 50 to 500-g. Samples.

4. The apparatus for analysis of samples containing coarser aggregate shall be the large extractor shown in Fig. 1, consisting of a large brass cylinder, through the bottom of which projects a 16-candle-power incandescent carbon filament bulb to supply heat to the extraction apparatus proper, which is held in the upper portion of the cylinder. This apparatus is composed of a cylindrical brass vessel for holding the solvent, a cylindrical wire basket made of 80-mesh wire cloth suspended in the cylinder, and an inverted conical condenser which serves as a top.

IV. PROCEDURE.

(*A*) *Analysis of 10 to 30-g. Samples.*[2]

Procedure.

5. An ordinary Whatman or S. and S. Filter Thimble shall be dried and weighed. The weighed sample shall be placed in the thimble and 40 to 50 cc. of CS_2 poured over the sample. The thimble containing the sample shall be suspended under the condenser by a fine wire bail. The flask shall be cautiously heated by a steam-bath or electric heater just enough to vaporize the solvent. Cold water is circulated through the condenser. The heat evaporates the carbon disulfide in the flask. This condenses upon the condenser and drops back upon

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[1] See p. 870.

[2] This method and the method for analysis of larger samples are especially adapted for asphalt mastics, grouts and mastic cake. If the binder is coal-tar pitch, the "free carbon" constituent of the binder will remain with the mineral aggregate. The committee has under consideration a possible separate method for analysis of coal-tar mastics.

the sample through which it filters, thus dissolving out the bitumen which collects in the bottom of the flask.

The extraction should be discontinued when the CS_2 drops colorless from the filter. The time of extraction will depend upon the nature of the bitumen and mineral aggregate in the sample and upon the degree of heat applied, the coldness of the water in the condenser and other factors. In some cases extraction may be complete in one hour, in others four or five hours may be necessary.

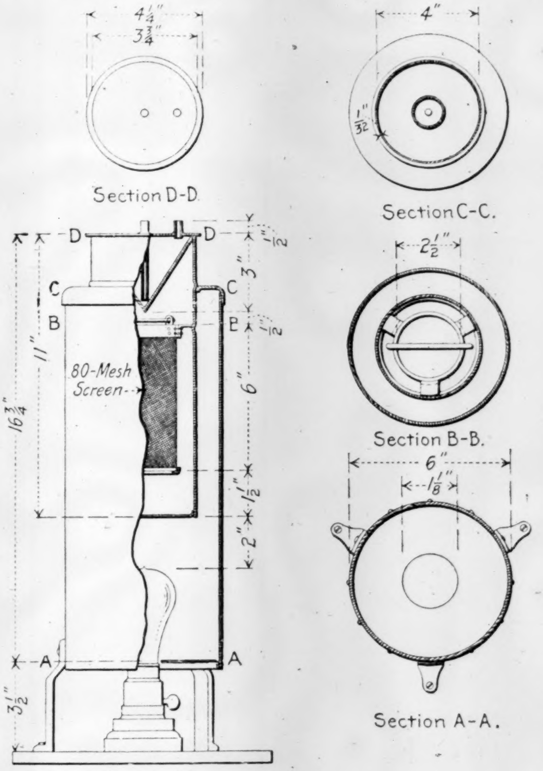

FIG. 1.

When the solvent comes through clear, the filter shall be removed and washed with a fine jet of CS_2 from a washing bottle to wash out any bitumen that may be retained at the top of the paper and to break up any channels that may have been formed by the CS_2 passing through. If the washings show any color, the thimble shall be put back and extraction continued until the solvent again becomes colorless. It shall then be removed, dried carefully, at a low temperature at first to prevent ignition of the absorbed CS_2, and finally to constant weight at 212° F., cooled and weighed.

The solution in the flask shall be rinsed into a weighed porcelain or silica evaporating dish or crucible and the solvent burned off under a hood. The residue shall be ignited over a flame or in a muffle and the ash weighed and the weight added to that of the mineral matter in the filter paper. This is to correct for the fine mineral matter which will be carried through the paper by the solvent. Should there be a considerable amount of ash recovered in this way, and if it is found that the mineral matter is calcium or other carbonate, it shall be recarbonated by repeated treatment with ammonium carbonate solution and finally ignited at a dull red heat. Ordinarily, however, the mineral matter going through the paper will be so small in amount that the difference caused by ignition may be neglected.

The corrected loss in weight on the original sample represents the percentage of bitumen.

The mesh analysis of the mineral aggregate shall be made in accordance with the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material, except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials.[1] The extracted residue shall now be transferred from the thimble to the 200-mesh sieve, the paper being gently rubbed to free adhering particles.

The aggregate on the sieve shall be gently rubbed with the fingers to break up lumps and to free any particles of fine dust that might adhere to larger sand particles. The sieve shall be shaken over a piece of paper from side to side with the right hand, striking it sharply against the palm of the left hand until no appreciable amount of dust comes through the sieve on to the paper. The paper shall be cleared from time to time by raising one side with the left hand and rolling off the siftings, so that it can be seen when the sifting is complete.

The material remaining on the 200-mesh sieve shall be weighed and the amount of 200-mesh material which has passed through shall be determined by difference.

This operation shall be repeated upon the coarser sieves in order and the amount passing each sieve and retained on the next finer recorded as percentage of the original sample.

(*B*) *Analysis of 50 to 500-g. Samples.*

6. A large filter paper, 12 or 13 in. in diameter, shall be fitted inside the wire basket of the extractor by folding once more than in

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[1] 1921 Book of A.S.T.M. Standards.

ordinary filtering, or by wrapping it over a form which fits inside the basket (a cylindrical bottle of proper size makes a good form) and placing it inside the basket.

The basket with contained filter paper shall be dried and weighed. The sample shall be weighed and packed in the filter paper in the basket. Care should be taken not to pack all coarse particles in one place and the fine particles in another but to have them mixed together in uniform proportions.

The sample shall be covered with a disk of felt or wad of absorbent cotton to insure even distribution of the dropping solvent, thus preventing it from forming a channel through the sample. The basket shall be suspended in the extractor and 150 to 200 cc. of CS_2 poured over the felt or cotton. The condenser shall be placed over the top and water circulated through it. Current shall be started through the electric lamp underneath the extractor and the extraction carried on exactly as in the smaller glass extractor, but on a larger scale. The time for extraction will vary from 3 to 12 or more hours, depending upon the nature of the sample.

To determine when extraction is complete, the condenser shall be raised and the basket lifted out to observe if drippings are clear. One or two drops caught upon white filter paper should leave but a light stain.

The drying and weighing of the basket, burning off of the solution for correction, and the sifting of the mineral aggregate shall be carried on exactly as in the case of the smaller sample as described in Section 5, except that in sifting mineral aggregates containing coarse stone, it is well to remove the stone by putting the mineral aggregate first through a 10-mesh sieve, as the large stone would injure the 200-mesh sieve.

The stone removed by the 10-mesh sieve may be screened through $\frac{1}{4}$-in., $\frac{1}{2}$-in., and coarser screens in order, as described in the Standard Method of Mechanical Analysis of Broken Stone or Broken Slag, except Aggregates used in Cement Concrete (Serial Designation: D 18) of the American Society for Testing Materials[1] and the fine material passing the 10-mesh sieve through 200-mesh and coarser sieves in order, all amounts passing any one screen or sieve and retained on the next finer one being reported as percentage of the original sample.

Thus the ingredients of the mixture may be roughly separated by the use of the proper sized sieves, and examined for physical and chemical characteristics.

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[1] 1921 Book of A.S.T.M. Standards.

NOTE.—The siftings passing the 200-mesh sieve will consist largely of the dust or pulverized rock used in the mixture. The material between the 100-mesh and 10 mesh will consist largely of the sand used in the mixture, with any particles of fine crushed stone within these limits that existed in the original materials. Gravel or broken stone as a rule will be larger than 10 or 8 mesh.

Carbon tetrachloride, benzol, or chloroform may be used instead of carbon disulfide, with the only difference that in the case of non-inflammable solvents, the solvent will have to be evaporated from the solution of bitumen to determine the ash for correction instead of burning off directly. When the solvent is expelled, the bitumen can be ignited for ash.

(C) *Recovery and Examination of Extracted Bitumen.*

7. The benzol solution containing the asphalt shall be evaporated to a thick viscous liquid on a steam or water bath, then transferred to a steam oven at 105° C. (221° F.) until its weight is nearly equal to the percentage of asphalt calculated in accordance with Section 5. It shall then be transferred to a hot plate and heated carefully with stirring at a temperature not exceeding 121° C. (250° F.) until its weight is exactly that determined in accordance with Section 6.

(D) *Solubility of Aggregate in Hydrochloric Acid.*

8. Where the mastic is to be used for acid-proof floors, tank linings, etc., pulverized silica and other materials insoluble in acid are used in preparing the mixture. The most important chemical property, therefore, is solubility or insolubility in mineral acids. This determination may be carried out in the following manner:

About 2.5 g. of the dust, or of the coarser material, or stone which has been previously pulverized in a mortar shall be dried to constant weight at 325° F. The loss will represent any moisture that may have been retained in the material as well as any absorbed solvent that may not have been expelled while drying the sample after extraction.

A 1-g. sample of the dried material shall be placed in a 250-cc. beaker, covered with a watch glass and 10 cc. of concentrated c. p. hydrochloric acid added, diluted with 50 cc. of distilled water. Any lumps shall be broken up by means of a glass stirring rod. Any effervescence which may occur shall be noted. If considerable effervescing takes place, the sample may be said to be carbonate. If all the sample, or practically all, dissolves, the determination need not be carried farther. If apparently insoluble, it shall be heated carefully, brought to boiling for 15 minutes and filtered through a tared Gooch filter, washing the insoluble residue with hot water. It shall be ignited and weighed and the loss reported as the percentage soluble in hydrochloric acid.

TENTATIVE METHODS OF TESTING INSULATING VARNISHES.[1]

Serial Designation: D 115 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1922; 1923.

Material Covered

1. These tests are intended for varnishes which are applied by brushing, dipping or spraying, and are primarily for the purpose of providing electrical insulation.

SPECIFIC GRAVITY.

Specific Gravity.

2. The specific gravity shall be measured with a pyknometer, Westphal balance or with a hydrometer so graduated that the specific gravity can be determined to 0.001. The temperature of the varnish shall be not less than 18° C. (64.4° F.) nor more than 22° C. (71.6° F.) and corrected to 20° C. (68° F.) by applying a correction of 0.0007 per 1° C. (0.0004 per 1° F.).

VISCOSITY.

Viscosity.

3. (*a*) The viscosity shall be determined with a Stormer or MacMichael viscosimeter and shall be stated in terms of the viscosity of distilled water determined with the same instrument under the same conditions. The short-tube type of efflux viscosimeter usually employed for lubricating oils is not acceptable. The temperature of the varnish shall be 20° C. (68° F.).

(*b*) The report shall include such details as the kind of instrument used, the size of the counterweight if a Stormer instrument is used, or the size of the wire in case the MacMichael instrument is used, etc.

FLASH POINT.

Procedure for Flash Point.

4. The flash point shall be determined in accordance with the Standard Method of Test for Flash Point of Volatile Flammable Liquids

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, Twenty-first St. and Clinton Ave., Irvington, N. J.

(Serial Designation: D 56) of the American Society for Testing Materials.[1]

TIME OF DRYING.

Test Specimen.

5. (*a*) Specimens for this test shall be pieces of thoroughly cleaned, smooth sheet copper or brass about 3 cm. (1.18 in.) wide and 20 cm. (7.88 in.) long and about 0.127 mm. (0.005 in.) thick.

(*b*) The specimen shall be dipped once in the varnish at a room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The consistency of the varnish shall be first so adjusted by trial that, when dry as determined in accordance with Section 7, the thickness of the film of varnish on each side of the metal shall be between 0.022 mm. (0.0009 in.) and 0.026 mm. (0.001 in.). Care shall be taken before dipping the specimens that the varnish has stood in the dipping tank for a sufficient length of time to be free from air bubbles.

Procedure.

6. (*a*) Specimens of air-drying varnish shall be dried in free air at a room temperature of approximately 20° C. (68° F.).

(*b*) In the case of baking varnishes, six specimens shall be dipped and allowed to drain at a room temperature of approximately 20° C. (68° F.) until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger will not become obliterated by further flow of the material. They are then to be dried in free air in an oven at approximately 100° C. (212° F.). At the end of the first 30 minutes, and again at the end of each 10-minute period thereafter, one specimen shall be taken from the oven and examined. In the case of slow-drying varnishes, this 10-minute period may be lengthened at the discretion of the operator.

Time of Drying.

7. The varnish shall be considered dry when a specimen will not stick to itself when folded and pressed together between the thumb and finger at a temperature of approximately 20° C. (68° F.).

DIELECTRIC STRENGTH TEST.

Dielectric Strength Test Specimen.

8. (*a*) Specimens for the dielectric strength test shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which shall be at the consistency prescribed in Section 5 (*b*).

(*b*) Each specimen shall be dipped twice, as specified in Section 5 (*b*), once in each direction, in order to give a more uniform thickness of coating. The specimen shall be dried after each dip in the same vertical position in which it was dipped.

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[1] 1921 Book of A.S.T.M. Standards.

(*c*) Specimens of air-drying varnish shall be dried in free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period 600 per cent longer than that determined in accordance with Section 7, provided such period does not exceed 24 hours.

(*d*) Specimens of baking varnish shall be drained and then baked after each dip for a period 300 per cent greater than that determined in accordance with Section 7 provided such period does not exceed 24 hours.

(*e*) The final thickness of the film of varnish on each side of the specimen shall be between 0.089 mm. (0.0035 in.) and 0.102 mm. (0.004 in.).

Procedure.

9. (*a*) The dielectric strength of the two films of varnish shall be determined by applying alternating potential to two circular metal disks, 3 cm. (1.18 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). The potential shall be applied at a low value and gradually raised at a rate such that puncture will occur in about ten to fifteen seconds. Ten such punctures are to be made at various points selected at random on each specimen. In each test the thickness of the films of varnish is to be determined as close to the point of puncture as practicable.

NOTE.—When necessary, in order to get ten punctures, an additional specimen should be tested.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined, and the voltage shall be measured by methods approved by the American Institute of Electrical Engineers.[1]

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 500 volts. The apparatus shall comply with the Standards of the American Institute of Electrical Engineers.

Dielectric Strength.

10. The volts at puncture, the net thickness of insulation and the volts per mil of net thickness shall be reported for each of the ten tests together with the average maximum amd minimum volts per mil.

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[1] Standards of the American Institute of Electrical Engineers.

WATER ABSORPTION TEST.

Procedure.

11. Specimens similar to those described in Section 8 shall be immersed in water at a room temperature of approximately 20° C. (68° F.) for a period of 24 hours. Upon removal from the water, the surface water shall be wiped off and dielectric strength tests made immediately as described in Section 9.

Dielectric Strength.

12. The volts at puncture, the net thickness of the insulation and the volts per mil of net thickness shall be reported for each of the ten tests, together with the average, maximum and minimum volts per mil.

HEAT ENDURANCE TEST.

Test Specimens.

13. For the heat endurance test, specimens shall be prepared as in Section 8. After removing not less than 1.27 cm. (0.5 in.) from one edge of the specimens, the number of strips required by Section 14 (*a*) shall be cut from the same edge, each 1.9 cm. (0.75 in.) in width.

Procedure.

14. (*a*) After setting as shown by the test indicated in Section 6 (*b*), the strips referred to in Section 13 shall be placed in a uniformly heated oven in which the temperature is maintained at 100° C. (212° F.) within ± 5° C. (9° F.). A strip shall be removed at the end of 1, 2, 4, 8 and 24 hours respectively and every 24 hours thereafter. These, together with the initial strip, shall be tested as follows at a room temperature of approximately 20° C. (68° F.).

(*b*) Each specimen shall be bent through 180 deg. over a rod 0.32 cm. ($\frac{1}{8}$ in.) in diameter. The number of hours of baking at which first cracking in the insulation occurs shall be noted and reported.

ACID AND ALKALI PROOF TEST.

Test Specimens

15. The specimens to be used for the test for acid and alkali proofness shall be brass rods 1.5 cm. (0.59 in.) in diameter, 15 cm. (5.90 in.) long and carefully rounded at one end to a radius of 0.75 cm. (0.295 in.). These specimens shall be dipped three times into the varnish, leaving exposed about 3 cm. (1.18 in.) of the rod at the end opposite the rounded end. Each coat shall be dried 25 per cent longer than the period determined in Section 7. Three specimens each shall be prepared for the acid and alkali solutions.

Procedure.

16. (*a*) The three specimens shall be suspended in the acid or alkali whose effect it is desired to determine to within 3 cm. (1.18 in.) of the end of the coated portion of the rod and suitable provision made for detecting the change in the electrical resistance between the rod and the solution. (Note 1.)

(*b*) It is recommended that these tests be made in 10-per-cent solutions as follows:

Sulfuric acid of sp. gr. 1.069 at 60° F. (15.5° C.) or nitric acid of sp. gr. 1.056 at 60° F. (15.5°) C.) or hydrochloric acid of sp. gr. 1.050 at 60° F. (15.5° C.) and sodium hydroxide of sp. gr. 1.115 at 60° F. (15.5° C.).

(*c*) The temperature of the solution shall be kept at approximately 20° C. (68° F.).

NOTE 1. A simple method is to connect a voltmeter between each rod in turn and one side of a 110-volt direct current circuit, the other side of the circuit being connected to the solution through any piece of suitable metal suspended in the solution. The resistance will be inversely proportional to the deflection of the voltmeter pointer, that is, the smaller the deflection, the greater the resistance. Failure of the material will, therefore, be indicated by a sudden increase in the deflection of the voltmeter pointer.

Acid and Alkali Proofness.

17. The resistance between each rod and the solution shall be measured once per day and the number of days elapsing before breakdown occurs shall be taken as the "proofness" of the varnish.

OIL TEST.

Oil Test Specimen.

18. For the test for the effect of oil, pieces cut from the specimens prepared for the dielectric strength test (Section 8) may be used after they have been punctured and measured.

Procedure.

19. The effect of oil on the varnish shall be determined by immersing the specimens in transformer oil at a temperature of 100° C. (212° F.) for 48 hours and noting the effect on the varnish as indicated, for example, by wiping with a piece of dry white cloth.

NOTE.—Incipient disintegration of the surface of the varnish may sometimes be detected by examining the oil for turbidity. If a specimen of the oil filtered through filter paper can be distinguished from an unfiltered sample when the two samples are held in front of a strong light, the oil is turbid.

DRAINING TEST.

(ALSO KNOWN AS "WORKING VISCOSITY" TEST)

Test Specimen.

20. A strip of bond paper 0.064 mm. (2.5 mils) in thickness, 10.2 cm. (4 in.) in width and 50.8 cm. (20 in.) in length, shall be immersed in the varnish at a room temperature of approximately 20° C. (68° F.) up to a line previously drawn across the paper a few inches from the top. The paper shall be withdrawn at a slow and uniform rate, care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried

or baked (according to the type of the varnish) until dry as determined in accordance with Section 7.

Measurements. 21. The thickness of the specimen in mils shall be measured at points 5.1 cm. (2 in.), 17.8 cm. (7 in.) and 30.5 cm. (12 in.), respectively, from the line to which the specimen was immersed.

Report. 22. The thickness of each film in mils at the three points specified in Section 21 shall be recorded. The difference between the thickness at the upper point (5.1 cm.) and that at the lower point (30.5 cm.) shall be taken as a measure of the variation in the film thickness caused by draining.

EVAPORATION TEST.

Procedure. 23. One hundred cubic centimeters of the varnish shall be placed in a flat-bottom crystallizing dish approximately 75 mm. (2.95 in.) in diameter and 45 mm. (1.77 in.) in height. It shall be heated to a temperature of 100° F. (37.8° C.) ± 2° F. (1.1° C.) for a period of 7 hours, the sample being exposed to still air in the open room.

Evaporation. 24. The decrease in volume of the sample shall be taken as the evaporation, this decrease being determined by noting the amount of water or kerosene that must be added to fill the dish to the original level.

NOTE.—This test is relative only. That is, it is only suitable for comparing one varnish with another when the tests are made simultaneously under exactly the same conditions.

TEST FOR NON-VOLATILE MATTER.

Procedure. 25. A portion of the sample shall be placed in a stoppered bottle or weighing pipette and weighed. About 1.5 g. of the sample shall be transferred to a weighed flat-bottom metal dish about 8 cm. (3.15 in.) in diameter, such as the cover of a friction-top tin can. The container shall again be weighed and the exact weight of the portion of the sample transferred to the weighed dish calculated by difference. The dish with its contents shall be heated for three hours in an oven maintained at 105 to 110° C. It shall then be weighed after cooling.

Non-Volatile Matter. 26. The ratio of the weight of the residue to that of the original sample expressed as a percentage shall be taken as the percentage of non-volatile matter in the varnish.

TENTATIVE METHOD OF TEST
FOR
DIELECTRIC STRENGTH OF SHEET AND TAPE INSULATING MATERIALS UNDER MOMENTARY DIELECTRIC STRESS.[1]

Serial Designation: D 149 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923

Scope. 1. This test is intended to determine the dielectric strength of sheet and tape materials for electrical insulation, under voltage stresses of short duration. It should not be considered as indicating the permanent dielectric strength of the material, as breakdown will take place at a lower voltage when applied for a greater length of time. It should also be noted that the results with the two procedures specified for sheet material and tape material, respectively, are not comparable because the apparent dielectric strength of thin materials varies with the area of the electrodes.

I. APPARATUS.

High Voltage Transformer. 2. (*a*) Any well designed, high tension transformer connected to an alternating current supply; having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1924, to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, Twenty-first St. and Clinton Ave., Irvington, N. J.

(*d*) Some protection is desirable in the high tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high tension terminals, it should not be greater than that which will limit the high tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the standardization rules of the American Institute of Electrical Engineers.

Electrodes. 3. The electrodes shall be of brass or copper with flat polished contact surfaces. For sheet material they shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.). For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.).

II. TEST SPECIMENS.

Test Specimens. 4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

III. PROCEDURE.

5. The tests shall be made in air with the specimen at room temperature. **Surrounding Medium.**

6. The testing electrodes shall be kept clean and polished. **Condition of Electrodes.**

7. The electrodes shall be self aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them. **Position of Electrodes and Specimen.**

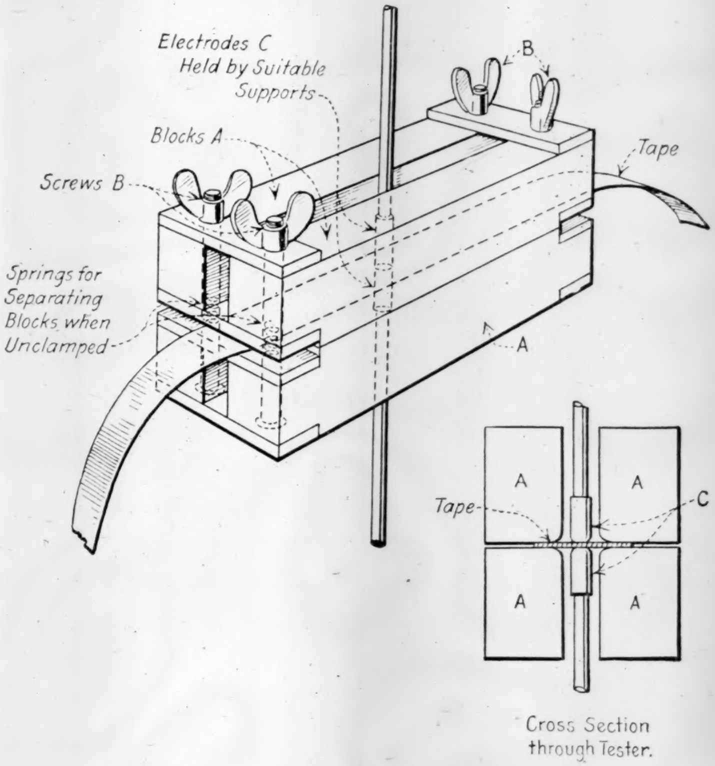
Electrodes C
Held by Suitable
Supports
B
Blocks A
Tape
Screws B
Springs for
Separating
Blocks when
Unclamped
A
A
A
Tape
C
A
A
Cross Section
through Tester.

FIG. 1.—Elementary Form of Tape Tester.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the appendix are shown two different devices which have been found satisfactory for these tests.

9. Starting at zero, the testing voltage shall be increased uniformly at such a rate that puncture will take place in from 10 to 15 seconds. **Application of Voltage.**

Number of Tests. 10. Ten tests shall be made and the average of these ten puncturing voltages shall be taken as the momentary dielectric strength of the sample.

Thickness. 11. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

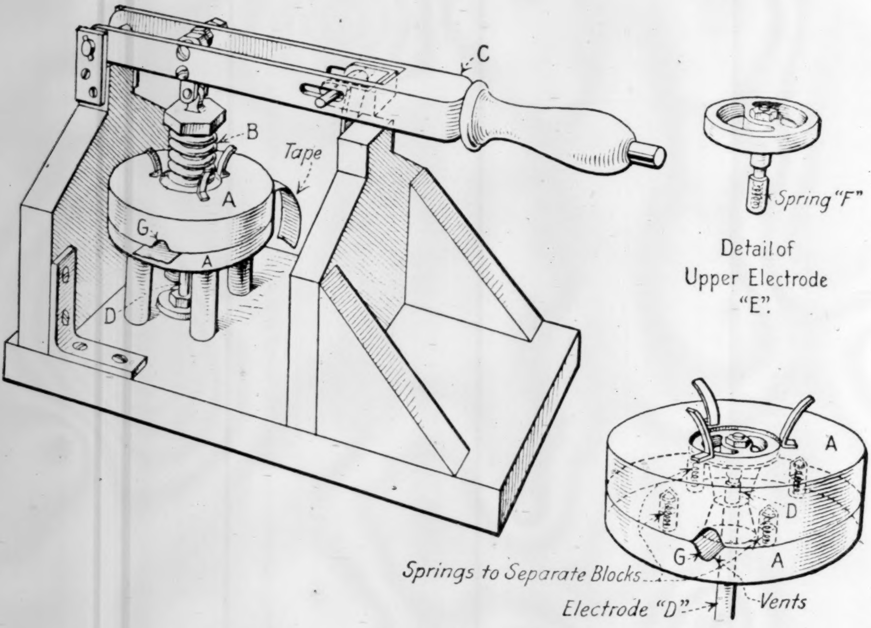
C
B
Tape
A
G
A
D
Spring "F"
Detail of Upper Electrode "E".
A
D
G
A
Springs to Separate Blocks
Electrode "D"
Vents

FIG. 2.—Lever-Operated Form of Tape Tester.

Report. 12. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent.

APPENDIX.

Referring to Fig. 1, the four wooden clamping blocks, *A*, are held together by the screws *B*. These blocks are impregnated with paraffin which assists in sealing the joints between the wooden blocks and the tape. The electrodes are introduced into the space between the blocks at *C*. The tape can be advanced through the blocks, for each shot, by opening and closing the clamping screws. In order to secure satisfactory results, the blocks must have accurately finished surfaces and should be carefully aligned.

Referring to Fig. 2, the two impregnated wooden clamping blocks, A, are pressed together by the spring, *B*, which is secured to the latched handle, *C*. Releasing the latch allows the blocks, *A*, to be separated to insert the tape or examine the electrodes or contact surfaces of the blocks.

The lower electrode, *D*, is fixed in position with its top flush with the lower block *A*. The upper electrode, *E*, is removable and its contact face is pressed against the tape by the internal spring, *F*. The spring *B* seats on the electrode *E*, which rests on a shoulder in the block *A*.

The openings, *G*, provide the necessary vents for the arc which occurs when the tape under test fails. The successful operation of this device depends upon the accuracy of the contact faces of the blocks *A*, their alignment, the impregnation of the blocks *A* and the vent openings *G*.

TENTATIVE METHOD OF TEST FOR PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT OF ELECTRICAL INSULATING MATERIALS AT RADIO FREQUENCIES.[1]

Serial Designation: D 150 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923

1. This method of test is intended to apply to all solid electrical insulating materials.

The behavior of material under test at radio frequencies is fundamentally different from that at low frequencies.

In this test the phase difference of the dielectric is determined at a measured frequency by determining the effective resistance (or equivalent series resistance) and capacity of a condenser made up with the material as the dielectric. The dielectric constant is calculated from the measured capacity of such a condenser, and the thickness and area of the dielectric.

The dielectric power loss is proportional to the product of the dielectric constant and the phase difference.

I. APPARATUS.

Generating Circuit.

2. The circuit in which the radio frequency waves are generated is called the generating circuit. The source of radio frequency voltage shall be an electron tube oscillator the frequency of which can be varied over the range desired and which can be coupled loosely to the measuring circuit. It shall furnish sufficient power so that the presence of the measuring circuit will not reduce its output. The output of the oscillator must be very constant, as any variation in voltage will cause a much larger variation in the final results, because of the differential method used. For this reason it is highly desirable to have the

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1924, to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, Twenty-first St. and Clinton Ave., Irvington, N. J.

plate current supplied by a storage battery or other source of very constant power.

Measuring Circuit.

3. The circuit in which the electrical insulating material specimen is placed for test is called the measuring circuit.

This circuit is composed of:

A condenser employing the test specimen as the dielectric and two metallic surfaces as the conducting plates.

A standard condenser of a special design having negligible phase difference or power factor.

One or more special inductance coils.

A low-resistance thermo-element (preferably less than five ohms).

A special double-pole double-throw switch equipped with mercury wells.

A set of resistor links having direct current resistance values ranging from negligible to about 40 ohms.

A sensitive low-resistance wall galvanometer of the deflecting mirror type or other suitable type of indicating instrument.

The arrangement of the apparatus in the measuring circuit is shown in Fig. 6 of the Appendix.

Frequency Meter.

4. The instrument used to measure the frequency of oscillation of the current in the generating circuit is called a frequency meter or wave meter. This instrument may be of any commercial design covering the wave-frequency range of about 85.7 to 1500 kilocycles per second (corresponding to wave lengths of 3500 to 200 meters) and capable of calibration accurate to within 1 per cent over the wave-frequency range used.

II. TEST SPECIMEN.

Test Specimen.

5. (*a*) For testing molded materials, the test specimen shall be a disk having the dimensions shown in Fig. 13 of the Appendix. A raised rim about the circumference is provided to hold a layer of mercury to form the upper plate when the specimen is used as a condenser.

(*b*) For testing laminated stiff sheet materials, either circular or rectangular test specimens may be used and the specimen shall be of such dimensions that, after fixing the upper mercury surface diameter (or length and width) at 2 cm. less than that of the specimen, the electrical capacity shall be not less than 100 micro-microfarads (100 $\mu\mu$f.). Specimens 25.4 by 30.4 cm. (10 by 12 in.) are recommended for general use.

(*c*) For testing solid waxes the test specimen may be cast to the shape mentioned in either Paragraph (*a*) or Paragraph (*b*).

(*d*) For testing very thin or flexible sheet material, such as varnished paper or mica, tin-foil may be used as the conducting condenser plates. The instructions for capacity and relative areas of conducting plates given in Paragraph (*b*) apply here. Where necessary, a mixture of beeswax and petrolatum may be employed as an adhesive for the tin-foil.

(*e*) For testing films of insulating varnishes, lacquers, paints, etc., the test specimen shall be as specified for dielectric strength tests in Sections 8 (*a*), (*b*), (*c*), and (*d*) of the Tentative Methods of Testing Insulating Varnishes (Serial Designation: D 115 – 23 T) of the American Society for Testing Materials,[1] except that the consistency of the varnish need not be adjusted. The copper or brass plate shall be one condenser plate and tin-foil the other. The tin-foil sheet shall not be larger than 18 cm. (7.09 in.) square. Both varnish films may be tested individually.

III. PROCEDURE.

(*A*) *Phase Difference* (*power factor*).

Method. 6. (*a*) The phase difference (power factor) of two specimens shall be measured by the resistance-variation method[2] in the condition received at normal room temperature of about 20° C. (68° F.) and at 5 radio-frequencies between 98 and 1200 kilocycles per second (3050 to 250 meters) each.

(*b*) When practicable, the phase difference (power factor) of two specimens shall be measured by the same method and at radio frequencies within the same limits as mentioned in Paragraph (*a*) after the specimens have been immersed in water at a temperature of about 20° C. (68° F.) for 48 hours. The edges of the specimen shall have been protected from the action of the water by dipping it in melted paraffin to a depth of 10 mm. (0.394 in.). After removing the specimen from the water, the surface water shall be wiped off with a clean, absorbent cloth, being careful not to handle the paraffined edge, and then allowed to stand in the room away from drafts and direct sunlight for five minutes before making the measurements.

Electrodes. 7. The specimen shall be floated on mercury in a glass dish on an insulating support levelled by means of levelling screws. Sufficient mercury shall be poured on the upper surface of the specimen to cover that surface within the confines of the barrier. In the case of molded materials, the confining barrier shall be of the material of the specimen; in the case of stiff sheet materials, the confining barrier shall be a two-piece copper rectangle or ring made of 0.32-cm. ($\frac{1}{8}$-in.) square copper wire.

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[1] See p. 811.

[2] The principles of the resistance-variation method of measuring phase difference and dielectric constant are given in Bureau of Standards *Circular No. 74*, pp. 180–193.

Procedure. 8. The details of the method of testing for phase difference are given in the Appendix.

Calculations. 9. The values of phase difference in degrees shall be calculated from the formula:

$$\text{Phase difference in degrees, } \Psi^\circ = 3.60\, RCf \times 10^{-7}$$

where f = frequency in kilocycles per second;
R = measured resistance of specimen condenser in ohms;
C = measured capacity of specimen in micromicrofarads;

or

$$\text{Phase difference in degrees, } \Psi^\circ = 0.1079\, \frac{RC}{\lambda}$$

where R and C are the same as above and λ = the wave length expressed in meters.

(B) *Dielectric Constant.*

Method. 10. The capacity of a condenser in which the specimen is the dielectric shall be determined by comparison with a standard variable air condenser under the conditions prescribed for phase difference measurements in Sections 6 (*a*) and 6 (*b*) with the specimen arranged as in Section 7.

Procedure. 11. The details of the method of determining capacity are given in the Appendix.

Calculations. 12. The dielectric constant shall be calculated from the formula:

$$\text{Dielectric constant } K = \frac{CT}{0.0885\, S}$$

where C = the capacitance of the specimen in micromicrofarads;
T = the average thickness of the dielectric expressed in centimeters;
S = the area of the upper metallic surface expressed in square centimeters;

or

$$K = \frac{CT}{0.224\, S}$$

where C = the capacitance of the specimen in micromicrofarads;
T = the average thickness of the dielectric expressed in inches;
S = the area of the upper metallic surface expressed in square inches.

IV. REPORT.

Report. 13. The report shall include the following:

(*a*) The description of the material: *i. e.*, filler or base, binder, grade, color and average thickness;

(*b*) Room temperature and relative humidity;

(*c*) A curve for each specimen, showing phase difference (power factor) and dielectric constant plotted as ordinate values, and wave frequencies (wave lengths) as abscissa values for the specimen as received and when practicable after immersion in water for 48 hours. Each curve sheet will, therefore, show two phase difference and two dielectric constant curves;

(*d*) The phase difference and dielectric constant of each specimen at wave frequencies of 100 and 1000 kilocycles per second (3000 and 300 meters) as read from the curves for each of the two conditions and the average phase difference and dielectric constant and their product at these same frequencies.

APPENDIX.

DETAILS OF RESISTANCE-VARIATION METHOD OF MEASUREMENT OF PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT.

Introduction.—A test specimen for the measurement of phase difference and dielectric constant at radio frequencies consists of a piece of insulating material placed between metal plates, the whole constituting an electric condenser. It is quite convenient and satisfactory to use mercury or tin-foil as the metal for the condenser plates. The specimen of molded insulating material may be floated on mercury and a pool of mercury formed on top of the specimen, confined by the raised rim about the edge of the test specimen.

The phase difference of an electrical insulating material is

$$\psi = 90^\circ - \theta$$

where θ is the phase angle between the current flowing and the voltage across a condenser which has the space between its conducting plates filled with the insulating material. The voltage E (Fig. 1) across the condenser may be considered to be made up of a voltage $\frac{I}{\omega\ C}$ acting on the capacity and a voltage $R\ I$ acting on a resistance in series with the capacity. Thus, the condenser is, for the purpose of measurement, considered as equivalent to a pure capacity C with a resistance R in series with it (Fig. 2). This resistance is called "effective resistance" or "equivalent resistance" of the condenser, sometimes shortened to simply "resistance." This resistance is quite distinct from the direct-current or leakage resistance of the condenser.

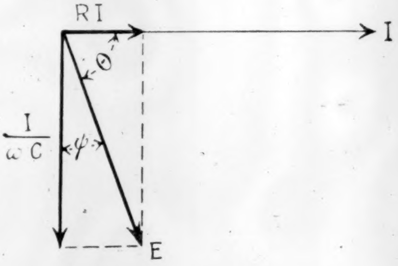

FIG. 1.—Vector Diagram.

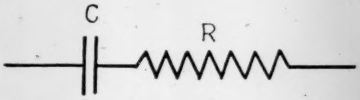

FIG. 2.—Condenser Circuit.

The phase difference ψ may be calculated from the effective resistance and other quantities as follows: From Fig. 1.

$$\tan\psi = \frac{R\ I}{\dfrac{I}{\omega\ C}} = \mathrm{R}\ \omega\ C\ .$$

where $\omega = 2\pi$ times the frequency of the current. Since for small angles $\tan \psi = \psi$, therefore

$$\psi = R\, \omega\, C.$$

The phase difference ψ is known if R, ω and C are known. The phase difference measurement thus involves a determination of three separate quantities. The formula $\psi = R\omega C$ is correct for ψ in radians, R in ohms and C in farads. With the wave length in meters (λ_m) in the formula instead of ω, ψ in degrees instead of radians, R in ohms, and C in micromicrofarads instead of farads,

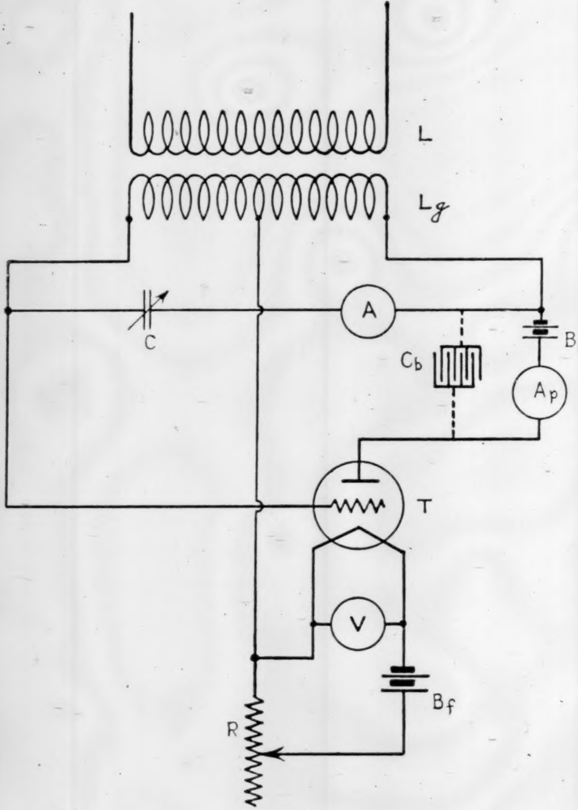

FIG. 3.—Radio-Frequency Generating Circuit.

$$\psi^\circ = 0.1079 \frac{R\ C}{\lambda_m}$$

The three quantities involved in the phase difference are measured with radio frequency currents. The current of a radio frequency is caused to flow in a circuit containing the condenser made up from the insulating material under test. The equivalent resistance (R) is determined by the resistance-variation method and the capacity is measured by comparison with a standard variable air condenser. The determination of the equivalent resistance is the most important and difficult part of the measurement. The wave frequency or wave length (λ) is measured by a wave-meter placed near the generating circuit.

From the measurement of the capacity C of the test specimen, the value of the dielectric constant of the insulating material is easily obtained. The average thickness T of the dielectric and the area S of the upper mercury surface plate are measured. The dielectric constant is

$$K = \frac{C\ T}{0.0885\ S}$$

where C is expressed in micromicrofarads, T in centimeters and S in square centimeters.

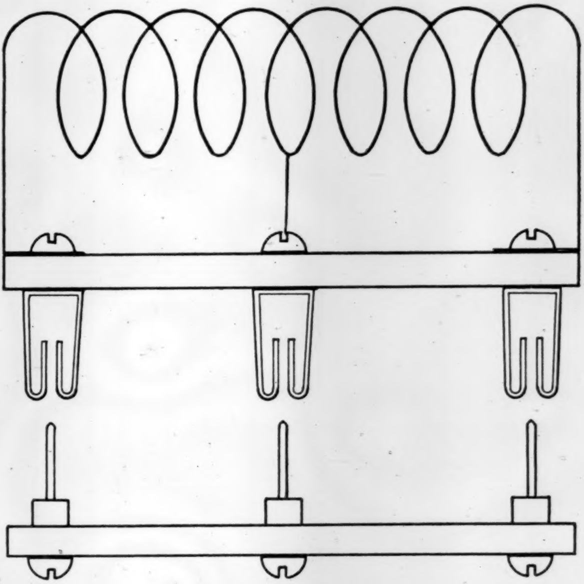

FIG. 4.—Secondary Inductance.

Circuits.—The measurement of phase difference and dielectric constant at radio frequencies requires a generating circuit and a suitable measuring circuit.

The generating circuit is shown schematically in Fig. 3. The inductance coil L_g is any one of a series of detachable tubular single layer inductors arranged somewhat as shown in Fig. 4. For the tests outlined in these specifications, it is probable that no more than five tubular inductors will be required. The smaller inductor may be made by winding 13 turns of wire on a $3\frac{1}{2}$-in. tube with 6 turns on either side of the middle clip. The larger inductor may be made by winding 112 turns of wire on a $6\frac{3}{4}$-in. tube, 32 turns on either side of the middle clip and 24 turns outside of both outside clips. The other three inductors may be made to cover the gap between these two extremes.

The variable air condenser C may be of any suitable commercial shielded type having a maximum capacity of about 0.003 microfarads (3000 micromicrofarads). The ammeter A is of the hot wire type having a range of 0 to 1 ampere. The by-pass condenser C_b may be any type of fixed condenser capable of withstanding 500 volts (direct current).

The plate battery B_p may be a 100 to 300-volt storage battery of the lead-acid type having an ampere capacity of about 0.2 ampere at the 8-hour discharge rate. Fig. 5 shows a 100-volt battery of this type with the supports fixed for stacking the batteries in an upright position. A lead couple and jar are also shown separately in this figure.

The ammeter A_p may be any type of direct-current instrument having a range of 0 to 50 milliamperes. The three-electrode electron tube T may be any of the so-called power tubes rated at 5 watts or over. The voltmeter V may be any type of direct-current instrument having a range suited to the type of electron tube used. The filament battery B_f should be of the lead-acid type whose voltage and ampere-hour capacity will be determined by the type of electron tube selected. The ampere carrying capacity and the resistance of the rheostat R would also be dependent on the type of tube selected.

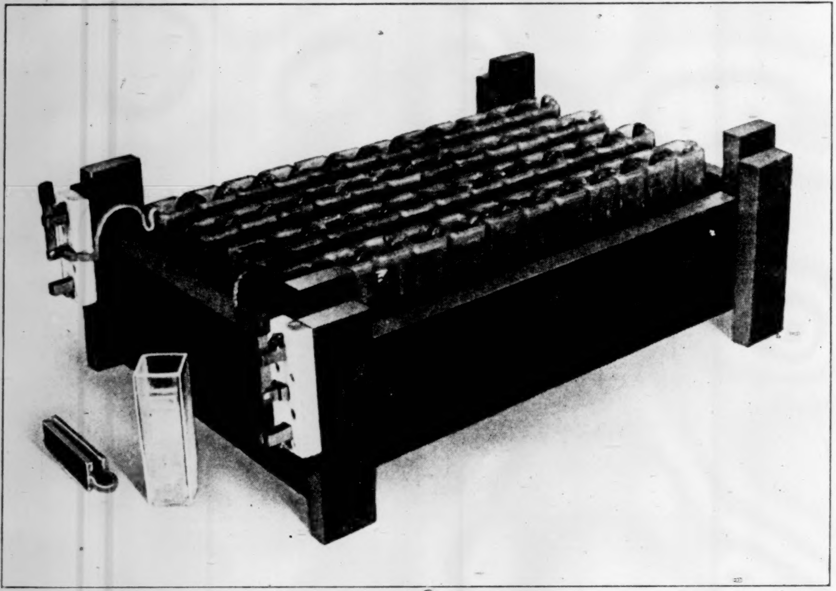

FIG. 5.—Storage Battery.

The measuring circuit is shown schematically in Fig. 6. The standard variable air condenser C_s may be of the Bureau of Standards standard type having a maximum capacity of not to exceed 0.001 microfarads (1000 micromicrofarads). Fig. 7 shows the general construction of this type of condenser. This condenser is described more fully in *Circular No. 74* of the U. S. Bureau of Standards, "Radio Instruments and Measurements," Section 32. The special switch with mercury wells, together with a non-inductive resistor are shown in Fig. 8. The special switch is constructed throughout of insulating material except the leads and wells which are of copper. The two upright standards of the switch are Pyrex glass rods about 1 cm. in diameter, while the supports which hold the six copper wells and leads are of Pyrex glass tubing. The copper wells are swaged to the copper leads and no solder used. The non-inductive resistor is made from a piece of glass tubing, two corks, two pieces of about No. 14 copper wire bent to form an *L* and a piece of small-diameter high-resistance wire. Several of these resistors are required, but in all cases the distance between the spurs should be the same, because the resistors must fit into the mercury wells, as shown in the switch (Fig. 8). Each of these units has a different value of resistance made so by varying either the length or the diameter of the resistance wire or both.

The condenser C_x is made either by floating the test specimen on mercury and pouring mercury on the upper surface until it is filled to the confining barriers or by the use of two sheets of tin-foil. The mercury bath on which the specimen rests is contained in a glass dish which rests on a piece of insulating material which in turn is supported by some sort of a levelling device.

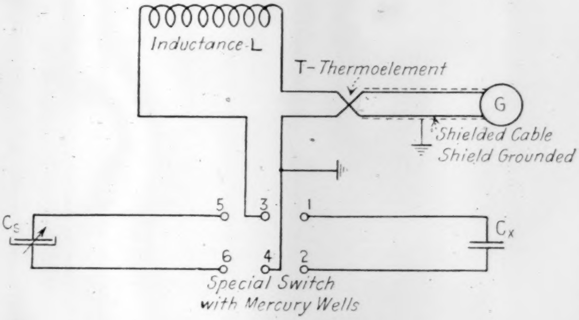

FIG. 6.—Measuring Circuit.

Fig. 9 shows the method of floating the specimen except that in this case a rectangular specimen is shown without a flange of the same material. A two-piece rectangular copper mercury retainer is used on the upper surface.

The standard inductor *L*, Fig. 6, may be of the type shown in Fig. 10, except that only standard binding posts will be required for connections. This inductor must be of some design having a comparatively low resistance so that the coil resistance will not be a large proportion of the combined equivalent resistance of the circuit made up of inductor *L* and the specimen condenser C_x. To cover the wave frequencies (wave lengths) named in these specifications, it would be desirable to have at least five inductors having inductance values of about 0.1, 0.5, 1, 2, and 3 millihenries.

The thermo-element *T* is of the crossed-wire type shown in Fig. 11. For this purpose the thermo-element base might better be equipped with four binding posts than with two binding posts and two clips. A cylindrical cap fits into the circular groove cut in the base and is held in place by a cap nut which screws on to the small brass bolt shown attached to the base. The wires used on this type of thermo-element may be of steel and "constantan" or "advance" about 0.02 mm. in diameter (see Bureau of Standards Radio

Laboratory Report cR251-2a). The resistance of the thermo-element should be from 3 to 5 ohms. A shielded cable connecting the thermo-element *T* to the galvanometer *G* may be standard lead-sheathed duplex cable.

The galvanometer *G* is a sensitive low-resistance wall galvanometer of the deflecting mirror type whose deflections within reasonable limits are proportional to the square of the current. A Leeds & Northrup No. 2285 high-sensitivity galvanometer with an external damping resistance of about 5 ohms, period about 2 seconds and concave mirror for about one meter focal distance has been found satisfactory.

Fig. 12 shows the complete apparatus as assembled in the Radio Laboratory of the Bureau of Standards. For more exact measurements the complete apparatus itself is housed in a small section of the room and completely surrounded with a fine mesh wire such as window screening. The purpose of this shielding is to insure the accuracy of measurement by shielding out the influence of outside radio-frequency generators. This view shows the wavemeter mounted on a tall stand, a rather complicated radio-frequency generator, a rack of 100-volt storage batteries, the bottle of distilled water for use with the batteries, the galvanometer rack showing the scale, lamp and galvanometer, the test specimen floated ready for measurement, the special skeleton switch, the standard inductor, the standard condenser and a box of non-inductive resistors. In addition, there will be observed a series of parallel wires between the generating circuit and the measuring circuit and also between the measuring circuit and the place occupied by the operator. The parallel wires between the generating circuit and the measuring circuit are all soldered together at the end nearest the operator (the left-hand end as shown), and left separate at the other end. The wire which connects all the parallel screening wires is then attached to a ground connection. The parallel wires between the measuring circuit and the operator are unattached at either end but all attached in the middle. This middle connector is also attached to the ground connection. The upper half of the shield between the operator and the measuring circuit is hinged to make it more easy to change the apparatus. It will be noticed that two panels of the over-all wire-netting screen have been removed in the photograph. The third

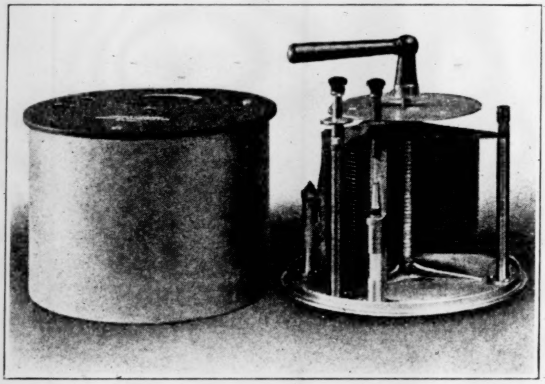

FIG. 7.—Standard Variable Air Condenser.

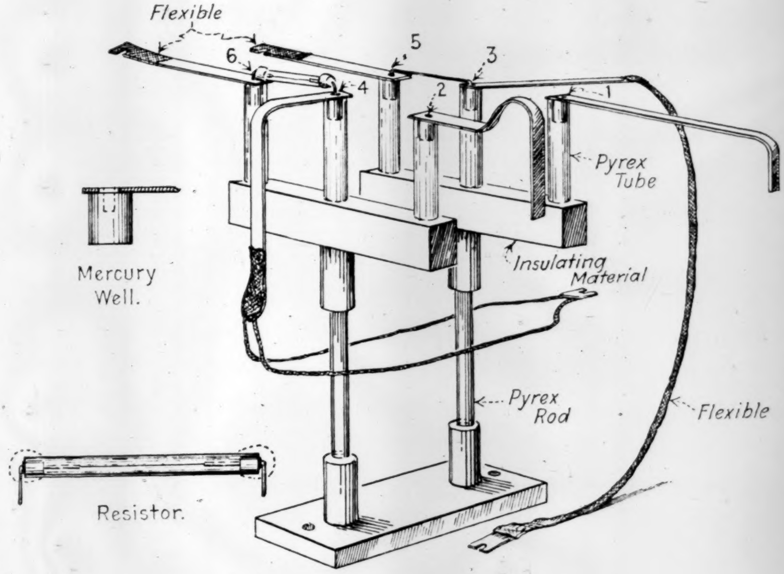
Flexible
5
6
3
4
2
1
Pyrex Tube
Mercury Well.
Insulating Material
Pyrex Rod
Flexible
Resistor.

FIG. 8.—Special Switch.

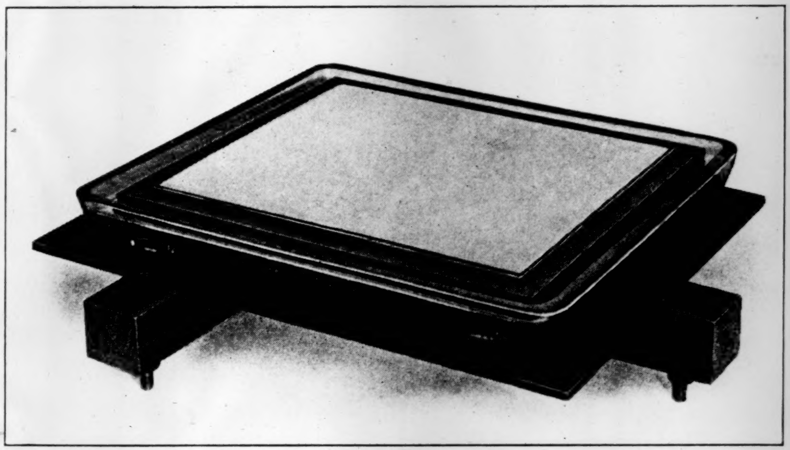

FIG. 9.—Test Specimen Floating on Mercury.

panel at the extreme right front of the photograph is hinged to form a door. This door permits the operator to arrange the test specimen in the mercury bath.

Method of Measurement.—Assume that the 13-turn inductor L_g is in position as shown in Fig. 3 and the other parts of the generating circuit are in readiness and generating radio-frequency current. Bring the generating circuit near to the measuring circuit with the shield of parallel wires between them as shown in Fig. 12. Put the 0.05-millihenry standard inductor *L* (Fig. 6) in position and insert heavy copper links between wells 1 and 3 and between 2 and 4. Write the value of the inductance *L* in Space No. 1 of the data sheet, Table I. Tune the generating circuit to the measuring circuit by varying the setting of the condenser *C* (Fig. 3), resonance being determined by the maximum deflection of the galvanometer *G* (Fig. 6). It is essential that this tuning be done carefully. Change the coupling between L_g and *L* until the maximum deflection at resonance is about 40 cm. if a 50-cm. scale is used. Leave the generating circuit untouched and determine the wave frequency (wave length) emitted by the generating circuit by means of a frequency meter (wave meter). Record the wave-meter setting in Space No. 2, Table I. Remove the wave meter. Remove the copper link on the grounded side (that is between wells 2 and 4) and read the zero error of the galvanometer and record the value in Column No. 1 of the data sheet. Reinsert the copper link and record the maximum deflection in Column No. 2. Record the resistance of the heavy copper link as 0 in Column No. 5. Remove the copper link spanning wells 2 and 4 and read the zero deflection of

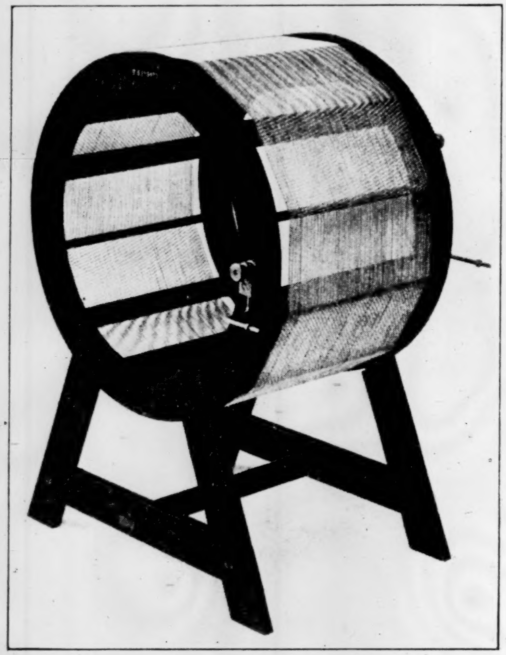

FIG. 10.—Standard Inductor.

the galvanometer. Insert this as the second entry in Column No. 1. Pick out a non-inductive resistor of such resistance that it will cut the galvanometer deflection to about half the maximum value and insert between wells 2 and 4 to replace the copper link. Record the galvanometer deflection as a second entry in Column No. 2 and the ohmic resistance of the resistor as a second entry in Column No. 5. Assuming the copper link to be *A* and three non-inductive resistors of increasing resistance values to be *B*, *C*, and *D*, insert the several links (*A*, *B*, *C*, and *D*) on the grounded side of the switch between wells 2 and 4 in the order *AB*, *AC*, *AD*, *AC*, *AB*. Record each zero error and maxi-

TABLE I.—SAMPLE RECORD OF TEST.

Date of Test,..........................Specimen No.,..........................Test No.,..........................
Specimen Submitted by,..........................Number Submitted,..........................Date,..........................
Base or Filler,..........................Binder,..........................Grade,..........................Color,..........................
Dry Bulb,........° C........° F. Wet Bulb,........° C........° F. Relative Humidity,........%
Notes..

Average thickness (*T*)....................(*No. 11*) cm. (*No. 11*) in.
Standard Inductance, (*No. 1*) mh.
Setting of $\left\{\begin{array}{l}\text{Wavemeter, } (No.\ 2) \text{ deg.}\\ \text{Stand. Cond. No., } (No.\ 4),\ (No.\ 3) \text{ deg.}\end{array}\right.$
Upper plate area (*S*)....................(*No. 12*) cm.^{2} (*No. 12*) in.^{2}
Wave Freq., *kc*/sec., (*No. 5*) f.
Wave Length, (*No. 6*) Meters.
Specimen Capacity, (*No. 7*) $\mu\mu f$.
Phase Difference, $\Psi°$ of $\left\{\begin{array}{l}\text{Specimen, } (No.\ 8) \text{ deg.}\\ \text{Circuit, } (No.\ 9) \text{ deg.}\end{array}\right.$
Power factor of Specimen, (*No. 10*) %.
Dielectric Constant, $K = (No.\ 13)$.
Phase difference×Dielectric Constant, $\Psi° \times K = (No.\ 14)$.

Galvanometer.				Resistance Inserted, R_1	$2\sqrt{\frac{d_o}{d_1}}-1$	Total Equiv. Resistance, *R*	Equiv. Res. of C_x, R_x
Zero Deflection.	Maximum Deflection.	True Deflection.	Mean Deflection.				
0.30	41.70	41.40	41.40	*A* 0	.....	.....	22.08
0.32	15.00	14.68	14.69	*B* 18.01	0.679	26.53	.....
0.32	41.70	41.38	41.40	*A* 0	.....	.....	.....
0.33	13.67	13.34	13.36	*C* 20.21	0.761	26.56	.....
0.33	41.70	41.37	41.37	*A* 0	.....	.....	.....
0.38	12.81	12.43	12.43	*D* 21.84	0.825	26.48	.....
0.38	41.79	41.41	.....	*A* 0	.....	.....	.....
0.36	13.75	13.39	.....	*C* 20.21	.....	Ave.	.....
0.37	41.77	41.40	.....	*A* 0	.....	.....	.....
0.39	15.09	14.70	.....	*B* 18.01	.....	26.52	.....
0.49	41.71	41.22	41.23	*A* 0	.....	.....	.....
0.52	17.35	16.83	16.84	*B* 2.51	0.565	4.44	.....
0.50	41.74	41.24	41.24	*A* 0	.....	....	.....
0.52	14.91	14.39	14.40	*C* 3.08	0.692	4.45	.....
0.50	41.77	41.27	41.27	*A* 0	.....	....	.....
0.52	11.42	10.90	10.90	*D* 4.20	0.947	4.43	.....
0.53	41.78	41.25	.....	*A* 0	.....	....	.....
0.53	14.93	14.40	.....	*C* 3.08	.....	Ave.	.....
0.53	41.77	41.24	.....	*A* 0	.....	....	.....
0.55	17.39	16.84	.....	*B* 2.51	.....	4.44	.....

mum deflection in the proper place in Columns Nos. 1 and 2 and the value of resistance inserted in the circuit in Column No. 5. Remove the links from the wells 1 to 3 and 2 to 4 and insert copper links between 3 and 5 and between 4 and 6. Move the generating circuit about 50 cm. away from the standard inductor L, being careful not to change the setting of any of the variables in the generating circuit. Check the wave frequency of the generating circuit. Tune the measuring circuit (composed of the standard condenser C_s, standard inductor L, the thermo-element T and the galvanometer G) to the generating circuit by varying the setting of the standard condenser C_s. Change the coupling between L_g and L to give about 40 cm. galvanometer deflection on the 50-cm. scale. Tune the measuring circuit very carefully but do not vary any controls on the generating circuit. Read the setting of the standard condenser C_s and record in Space No. 3. If more than one standard condenser is available in the laboratory, record the number of the condenser used in Space No. 4 for the purpose of identification. Remove the copper link from between wells 4 to 6, read the galvanometer zero deflection and record the value in the first column of the data sheet (see 0.049, Column

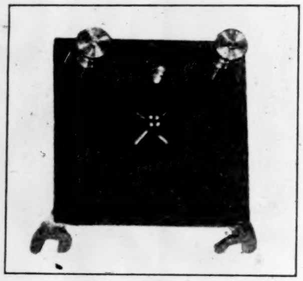

FIG. 11.—Thermo-element.

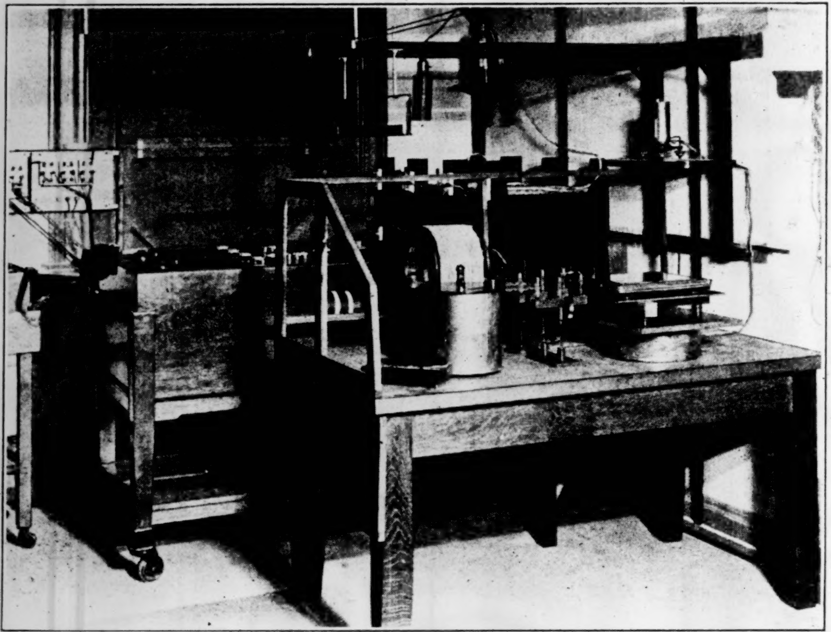

FIG. 12.—Complete Apparatus as Installed in Radio Laboratory, U. S. Bureau of Standards.

No. 1). Reinsert the copper link and read the maximum galvanometer deflection, record the numerical value in Column No. 2. Proceed in this manner, as above described, inserting resistors in the order *AB*, *AC*, *AD*, *AC*, *AB*.

The data in the body of the data sheet may now be computed. Column No. 3 is obtained by subtracting the zero deflection from the corresponding maximum deflection. Thus 41.70 – 0.30 = 41.40, the true deflection, or 15.00 – 0.32 = 14.68. Column No. 4 is obtained by averaging; that is, the two *A* deflections which precede the two *B* deflections, the two *B* deflections, the two *A* deflections which precede the two *C* deflections and the two *C* deflections are averaged. Thus, the average of 41.40 and 41.40 is 41.40 and of 14.68 and 14.70 is 14.69. As has been stated, phase difference

$$\psi^\circ = 0.1079 \frac{R\,C}{\lambda}$$

The equivalent resistance *R* is computed in three steps and recorded in Column No. 8. By one measurement the equivalent resistance (R_x) of the condenser C_x plus the resistance (R_c) of the remainder of the circuit, including the inductor *L*, is determined. By another, the equivalent resistance (R_s) of the standard condenser C_s and the resistance (R_c) of the remainder of the circuit, including the inductor *L*. Since in each case the remainder of the circuit is the same and the standard condenser C_s is considered to have negligible resistance, the difference of the resistance values will be the equivalent resistance of the specimen condenser C_x. That is, the resistance of the condenser C_x plus the resistance of the circuit is $R_x + \mathrm{R}_c$, while the resistance of the standard condenser C_s plus the resistance of the circuit is $R_s + R_c$. R_s is negligible, so $R_s + R_c$ is equivalent to R_c. $(R_x + R_c) - R_c = R_x$ = the equivalent resistance of C_x.

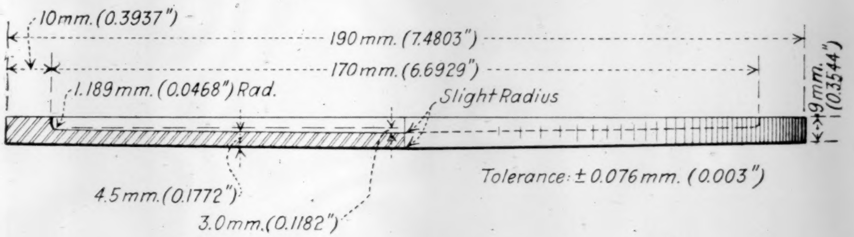

FIG. 13.—Molded Test Specimen.

The combined equivalent resistance of the specimen condenser and its attached circuit is computed first.

$$\text{The equivalent resistance } R = \frac{R_1}{\sqrt[2]{\frac{d_o}{d_1}} - 1}$$

where R_1 = resistance inserted,
d_1 = galvanometer deflection with R_1 inserted,
d_o = galvanometer deflection with no resistance inserted.

The denominator is solved first and its values inserted in Column No. 6, while the values of R are inserted in Column No. 7. Thus, the values in Column No. 6 are

$$\sqrt[2]{\frac{41.40}{14.69}} - 1 = 0.679, \quad \sqrt[2]{\frac{41.40}{13.36}} - 1 = 0.761, \text{ and } \sqrt[2]{\frac{41.37}{12.43}} - 1 = 0.825.$$

The equivalent resistance R (Column No. 7) is obtained by dividing the ohmic resistance of the resistors B, C, and D by their respective denominators as shown in the above equation. Thus, the values of R are

$$\frac{18.01}{0.679} = 26.53, \quad \frac{20.21}{0.761} = 26.56, \quad \frac{21.84}{0.825} = 26.48.$$

The same procedure is followed to determine the resistance of $R_s + R_c$. As shown in the data sheet, these values are found to be 4.44, 4.45 and 4.43 ohms. The next step is to average each group of three resistances. The equivalent resistance of the specimen condenser C_x is the difference between these averages, or $26.52 - 4.44 = 22.08$ ohms. The next step is to fill in Spaces Nos. 5, 6 and 7 by referring to the calibration charts of the wave meter and the standard condenser. With these values available, the phase difference, or power factor of the specimen, may be computed. As has been previously stated, phase difference expressed in degrees is

$$\psi^\circ = 3.60\ RCf \times 10^{-7}$$

or

$$= 0.1079\ \frac{RC}{\lambda}$$

Assuming the specimen capacity (C) to be 235 micromicrofarads, the wave frequency (f) to be 1000 *kc* per sec. (wave length 300 meters), then the phase difference of the specimen is

$$\psi^\circ = 3.60 \times 22.08 \times 235 \times 1000 \times 10^{-7} = 1.87 \text{ deg.}$$

or

$$= \frac{0.1079 \times 22.08 \times 235}{300} = 1.87 \text{ deg.}$$

This value is inserted in Space No. 8 while the phase difference of the circuit is computed and inserted in Space No. 9. Thus the phase difference of the circuit equals:

$$3.60 \times 4.44 \times 235 \times 1000 \times 10^{-7} = 0.38 \text{ deg.}$$

or

$$\frac{0.1079 \times 4.44 \times 235}{300} = 0.38 \text{ deg.}$$

For the small values of phase difference usually found in the better types of electrical insulating material,

$$\text{power factor in per cent} = 1.75 \times \psi^\circ.$$

This quantity is computed and entered in Space No. 10. The thickness and area of the specimen may now be measured and the values written in Spaces Nos.

11 and 12, respectively. The thickness (T) should be the average of at least six micrometer readings. Having determined the thickness (T) and the area (S), and the capacity (C) (Spaces Nos. 7, 11 and 12), the dielectric constant may be computed from the formula previously given. Assuming T and S to be 0.45 cm. and 284 cm². respectively,

$$K = \frac{CT}{0.0885\ S} = \frac{235 \times 0.45}{0.0885 \times 284} = 4.2.$$

The computed value of K is written in Space No. 13. For the better comparison of electrical insulating materials for radio use, both the phase difference and the dielectric constant should be considered. Space No. 14 has been left for the numerical product of phase difference expressed in degrees and the dielectric constant. Thus,

$$\text{Product} = \psi^\circ \times K = 1.87 \times 4.2 = 7.86.$$

TABLE II.—SAMPLE REPORT.

Date of Test, ***May 10, 1922.*** Specimen Number, *1.*
Specimen submitted by *A B C Co.* Number submitted, 1. Date, *May 1, 1922.*
Base or Filler, ***Wood flour.*** Binder, *X Y Z Resin.* Grade, *No. 2.* Color, *Natural.*
Average thickness, *0.443* cm., ... in. Room temperature, *21*° C., ... °F.
Relative humidity, *54%.*

Wave Frequency, f, kilocycles per sec.	Wave Length, λ, meters.	Computed Values.				Remarks.
		Phase Difference, ψ°, deg.	Power Factor, per cent.	Dielectric Constant, K	Product of $\psi^\circ \times K$	
1071.0	280	2.04	3.57	5.20	10.6	As received.
492.0	610	1.92	3.36	5.28	10.1	
197.4	1520	1.91	3.34	5.34	10.2	
113.6	2640	1.86	3.25	5.37	10.0	
95.0	3160	1.84	3.22	5.40	9.9	
1027.0	292	2.12	3.71	5.40	11.4	After water treatment.
482.5	622	2.02	3.54	5.48	11.1	
195.5	1534	2.01	3.52	5.54	11.1	
112.5	2666	1.96	3.43	5.57	10.9	
93.8	3200	1.94	3.39	5.60	10.9	

Report.—A convenient form for the report is shown in Table II and a summary for 300 and 3000 meters is shown in Table III.

TABLE III.—SAMPLE SUMMARY.

Values of phase difference and dielectric constant, at 300 and 3000 meters wave length as read from curves, Fig. 14.

Wave Frequency.	Phase Difference, ψ°, deg.	Dielectric Constant, K	Product of ψ° × K
AS RECEIVED, AT 21° C.			
100 *kc* per sec. 3000 meters	1.84	5.39	9.92
1000 *kc* per sec. 300 meters	2.02	5.21	10.53
Average	1.93	5.30	10.23
AFTER 48 HOURS IN WATER AT 21° C.			
100 *kc* per sec. 3000 meters	1.94	5.60	10.86
1000 *kc* per sec. 300 meters	2.11	5.40	11.40
Average	2.02	5.50	11.13

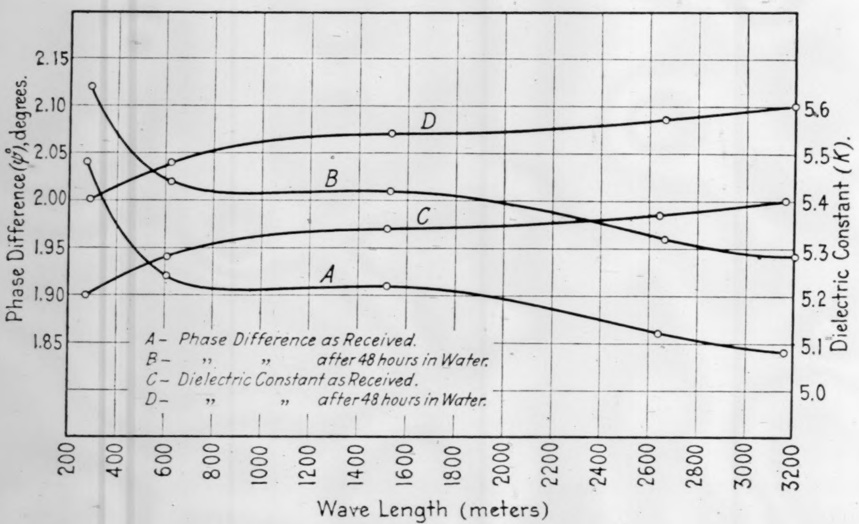

FIG. 14.—Curves for Test Specimen No. 1.

TENTATIVE METHOD OF TEST
OF
ELECTRICAL INSULATING MATERIALS FOR VOLTAGE EFFECTS AT RADIO FREQUENCIES[1]

Serial Designation: D 175 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

1. This method of test is intended to determine the dielectric failure and flash-over voltages of electrical insulating materials at radio frequencies.

The failure under radio frequency stress may take the form of charring, buckling, cracking, blistering, softening or chemical decomposition. Failure through the material is not abrupt and it, therefore, requires a certain amount of judgment on the part of the operator to decide just what constitutes failure in any particular case.

When a sheet of insulating material is tested between two metal electrodes passing through it, the heat generated increases with the thickness of the material, while the radiating surface remains nearly constant. Consequently, as the thickness of the sample is increased, the voltage at which failure occurs will decrease. As sufficient data are not available to allow results to be translated from one thickness to another, it is necessary that all comparative tests be made on samples of the same thickness. Hence, in the standard method given below, a definite thickness of sample is specified. This method, of course, is applicable to other thicknesses of material, but when so used the results should be compared only with similar tests made on like thicknesses of material.

In the flash-over test, heating of the material due to the high frequency current is to be avoided and it, therefore, is not so important that the samples being compared be of the same thickness. However, as a little heating is unavoidable it is also desirable in this test to compare samples of the same thickness whenever possible.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, Twenty-first St. and Clinton Ave., Irvington, N. J.

I. APPARATUS

Generating Circuit. 2. Any type of generator having an output of 500 watts or more and generating continuous waves of 100 and 1000 kilocycles per second, respectively, and at voltages up to 5000 or 10,000 volts, depending upon the class of materials tested, is satisfactory. If desired, a circuit similar to that shown in Fig. 1 may be used.

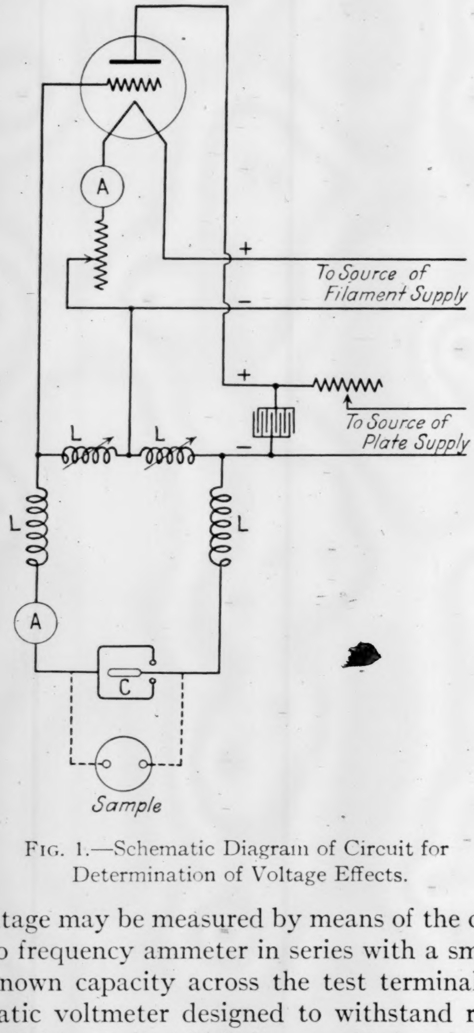


FIG. 1.—Schematic Diagram of Circuit for Determination of Voltage Effects.

Voltmeter. 3. The voltage may be measured by means of the current through a shielded radio frequency ammeter in series with a small shielded air condenser of known capacity across the test terminals or by means of an electrostatic voltmeter designed to withstand radio frequency potentials. Suitable scales shall be provided so that reasonable accuracy will be obtained when measuring any testing voltages up to the maximum desired.

If the ammeter method is used:

$$E \text{ (in volts)} = \frac{16I \times 10^7}{fC}$$

where I = current in amperes;
f = frequency in kilocycles per second;
C = capacity of air condenser in micro-microfarads.

NOTE.—In the above formula, the value 16 is an approximation, 15.92 being the exact value.

Frequency Meter. 4. The frequency meter or wave meter may be of any commercial design covering the required frequency or wave lengths and accurate to within ± 10 per cent over the wave frequency range used.

Electrodes. 5. (*a*) The electrodes shall be of brass and shall be clean and polished.

(*b*) For the dielectric failure test through the specimen the electrodes shall have the dimensions shown in Fig. 2.

(*c*) For the flash-over voltage test across the surface of the material, the electrodes shall have the dimensions shown in Fig. 4.

II. TEST SPECIMENS

Test Specimens. 6. (*a*) The specimens shall be representative of the material to be tested, care being taken to select material free from abnormal defects.

(*b*) For the dielectric failure test, the specimens shall be 6.35 mm. (0.25 in.) in thickness and may be of any convenient size or shape provided that the center electrode (see Fig. 3) is at least 57.5 mm. (2.264 in.) from the outside edge at all points. Other thicknesses may be used but the results therefrom should be used strictly for comparative purposes as explained under Section 1. If any samples are milled to reduce the thickness, care should be taken not to tear, chip or otherwise change the character of the material. Four holes 12.7 mm. (0.5 in.) in diameter, shall be provided in each specimen, one in the center and three equally spaced in a circle of 25.4 mm. (1.000 in.) radius as shown in Fig. 3.

(*c*) For the flash-over test, the specimens may be any convenient size, the holes being drilled on 38.1-mm. (1.5-in.) centers as shown in Fig. 4.

III. PROCEDURE

(*A*) *Dielectric Failure*

Surrounding Medium and Wave Frequency. 7. (*a*) Two specimens shall be tested in the condition received at normal room temperature of about 20° C. (68° F.), one of these at 100 kilocycles per second (3000 meters wave length) and the other at 1000 kilocycles per second (300 meters wave length).

(*b*) Similarly, an additional two specimens shall be tested respectively, at the frequencies specified in Paragraph (*a*) after the specimens have been immersed in distilled water at a temperature of about 20° C. (68° F.) for 48 hours. After removing the specimens from the water, the surface water shall be wiped off with a clean absorbent cloth and the specimens then allowed to stand in the room away from drafts and direct sunlight for 5 minutes. The holes shall be drilled before immersion.

Position of Electrodes in Specimens.

8. One electrode (Fig. 2) shall be inserted in the center hole in a specimen and a similar electrode in one of the other three holes. The electrodes must be a tight fit, otherwise corona may form at comparatively low voltage and destroy the material.

Connection of Electrodes to Test Terminals.

9. The electrodes shall then be connected to the test terminals of the radio-frequency generator. One side of the generator shall be grounded, and this terminal shall be connected to the center electrode of the specimen. The reason for this is that the failure generally occurs around the high potential terminal and this will allow the two subsequent tests to be made between the center and the other two holes, the center not being destroyed.

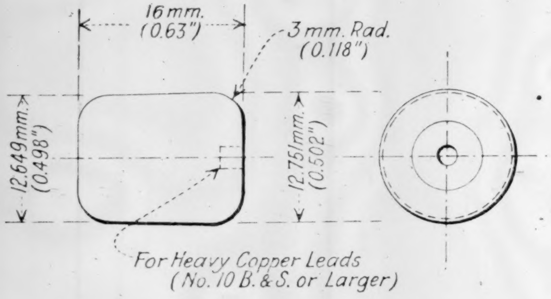


FIG. 2.—Showing Dimensions of Electrodes.

Application of Voltage.

10. For materials which ordinarily fail below 3000 volts, the voltage shall be raised in steps of 500 volts. For materials which ordinarily fail above 3000 volts, the voltage shall be raised in steps of 1000 volts. Wherever possible, the initial voltage chosen shall be such that at least three voltage steps will be required to cause failure of the material.

Test Period.

11. The voltage at each step shall be impressed for two minutes, the testing period being counted from the instant when the prescribed voltage is reached, and the time required to reach this voltage not exceeding $\frac{1}{4}$ minute. Whenever samples thicker than that specified are used, this testing period should be changed to three minutes.

Number of Tests.

12. Tests shall be made between the center hole and each of the other three holes of each specimen, the specimens being allowed to cool to room temperature after each test.

The average of these three voltages shall be considered as the dielectric strength of the specimen under the conditions of the tests.

(*B*) *Flash-Over Voltage Tests*

Surrounding Medium and Frequency.

13. The flash-over tests shall be made under the same conditions and at the same frequencies as specified in Section 7.

Position of Electrodes.

14. The electrodes shall be clamped into position as shown in Fig. 4.

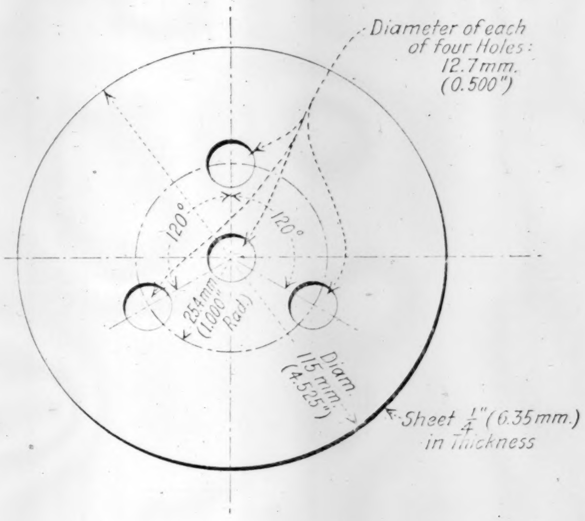

Diameter of each of four Holes: 12.7 mm. (0.500")
120°
120°
254mm (1.000" Rad.)
Diam. 115 mm. (4.525")
Sheet $\frac{1}{4}$" (6.35 mm.) in Thickness

FIG. 3.—Test Specimen.

Application of Voltage.

15. The voltage shall be raised at the rate of about 1000 volts per second until flash-over occurs. The power shall be removed immediately upon flash-over and the test shall be repeated (without moving the electrodes) until the insulation value has been practically destroyed.

NOTE.—The voltage may be increased either by varying the grid and plate inductances or capacities, or by varying the direct current plate voltage.

Test Period.

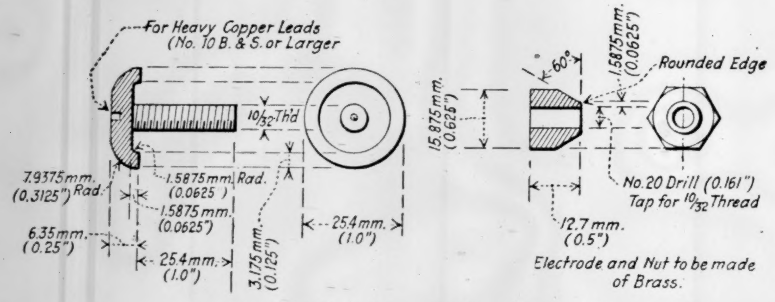
16. The initial voltage chosen shall be as little below the flash-over voltage as practicable so that the flash-over will occur as soon as possible without appreciable heating of the material.

Voltage Measurement.

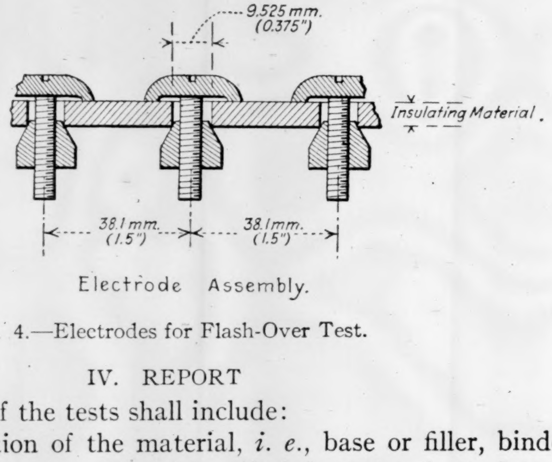
17. The voltage which exists across the specimen when flash-over takes place cannot be determined with the specimen in place since the voltage would not remain constant until a steady deflection of

the measuring instrument was reached and the sample would heat up. Therefore, with the tube generators, as soon as discharge occurs the plate voltage shall be thrown off, all other controls remaining constant, and the test leads removed. The plate voltage then shall be reapplied and the voltage measuring instrument reading taken when a steady deflection is reached.

Number of Tests. 18. Tests shall be made in at least three places on each side of each specimen.


For Heavy Copper Leads (No. 10 B. & S. or Larger
10/32 Th'd
7.9375 mm. (0.3125") Rad.
1.5875 mm. Rad. (0.0625")
1.5875 mm. (0.0625")
6.35 mm. (0.25")
25.4 mm. (1.0")
3.175 mm. (0.125")
25.4 mm. (1.0")
15.875 mm. (0.625")
60°
1.5875 mm. (0.0625")
Rounded Edge
No. 20 Drill (0.161") Tap for 10/32 Thread
12.7 mm. (0.5")
Electrode and Nut to be made of Brass.

Electrode and Nut.


9.525 mm. (0.375")
Insulating Material.
38.1 mm. (1.5")
38.1 mm. (1.5")

Electrode Assembly.

FIG. 4.—Electrodes for Flash-Over Test.

IV. REPORT

Report. 19. The report of the tests shall include:

(*a*) The description of the material, *i. e.*, base or filler, binder, grade, color and nature of surface of specimen between electrodes;

(*b*) Room temperature and relative humidity;

(*c*) Voltage at which each dielectric failure occurs, average voltage, duration of application of final voltage, and wave frequency.

(*d*) Maximum value of voltage attained in the flash-over voltage tests, wave frequency and the values obtained in the repetition of test;

(*e*) Distance between adjacent electrode edges;

(*f*) Thickness of specimen at electrodes;

(*g*) Nature of the "burn" on the specimen.

APPENDIX

SAMPLE RECORD OF TEST

Date of Test, ... Test No., ...
Specimens submitted by, ... Number Submitted, ... Date, ...
Base or Filler, ... Binder, ... Grade, ... Color, ...
Dry Bulb, ... ° C. Wet Bulb, ... ° C. Relative Humidity, ... %

Dielectric Failure Test

	Specimen Number			
	1	2	3	4
Thickness of specimen at electrodes (mm.)				
Distance between electrode edges (mm.)				
Duration of immersion tests (hours)				
Temperature of water (deg. Cent.)				
Frequency (kilocycles per second)				
Wave length (meters)				
Initial voltage				
Voltage at failure:				
First test				
Second test				
Third test				
Duration of Application of Final Voltage (seconds):				
First test				
Second test				
Third test				
Condition of material after failure:				
First test				
Second test				
Third test				

Flash-over Test

	Specimen Number			
	1	2	3	4
Thickness of specimen at electrodes (mm.)				
Distance between electrode edges (mm.)				
Duration of immersion test (hours)				
Temperature of water (deg. Cent.)				
Frequency (kilocycles per second)				
Wave length (meters)				
Initial voltage				
Voltage at first failure				
Voltage at second failure				
Voltage at third failure				
Voltage at fourth failure				
Voltage at fifth failure				
Voltage at sixth failure				
Condition of material after failure				

TENTATIVE METHODS OF TESTING CABLE SPLICING AND POTHEAD COMPOUNDS[1]

Serial Designation: D 176 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Material Covered. 1. These tests are intended to cover compounds used in cable splices and potheads.

I. PHYSICAL TESTS

Physical Tests. 2. Each of the following tests shall be made in accordance with the method of test applicable, of the American Society for Testing Materials, as indicated:

(*a*) *Melting Point:* Tentative Method of Test for Melting Point of Petrolatum (Serial Designation: D 127 - 22 T).[2]

(*b*) *Softening point*, for compounds having no definite melting point: Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36),[3] or

Standard Method of Test for Softening Point of Tar Products (Serial Designation: D 61).[3]

The method used should be indicated in the report.

(*c*) *Flash and Fire Points:* Tentative Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92 - 23 T).[4]

(*d*) *Evaporation:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6).[3]

(*e*) *Viscosity*, Temperature range from melting point to 150° C.: Saybolt Furol, Tentative Method of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88 - 23 T).[5]

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. S. Vassar, Secretary of Committee D-9 on Electrical Insulating Materials, Twenty-first St. and Clinton Ave., Irvington, N. J.

[2] *Proceedings*, Am. Soc. Testing Mats., Part I, p. 766 (1922).

[3] 1921 Book of A.S.T.M. Standards.

[4] See p. 690.

[5] See p. 672.

(*f*) *Penetration Test,* Temperature range from melting or softening point to $-25°$ C.: Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5).[1]

Brittleness. 3. To determine the brittleness of the material, the compound shall be spread on a piece of sheet metal in a layer $\frac{1}{16}$ in. in thickness. It shall then be submerged in water having a temperature at least 20° F. above the expected breaking point. It shall then be cooled 5° F. and held at this temperature for 5 minutes. The cooling shall then be continued in increments of 5° F. At each temperature interval the compounds shall be tested with the blade of a knife, inserting the point with the blade as nearly parallel with the sheet metal as is practicable, and pulling the compound from the sheet metal as rapidly as possible by rotating the blade about its back as an axis. The temperature at which the compound no longer stretches but snaps, shall be considered the breaking point.

II. DIELECTRIC STRENGTH TEST

Dielectric Strength. 4. (*a*) This test is intended to determine the dielectric strength of cable splicing and pothead compounds under voltage stresses of short duration. It is of value as a comparative test but does not indicate the permanent dielectric strength of these compounds.

(*b*) The dielectric strength of this class of material varies with the temperature. It is, therefore, recommended that a sufficient number of tests be made at different temperatures to establish the momentary dielectric strength - temperature curve from $-25°$ C. to $+100°$ C.

Sample. 5. A representative sample shall be taken from the original package, melted and poured directly into the testing container. Care should be used in melting and pouring the compound not to overheat it nor to entrap air. The electrodes should be heated to the approximate compound temperature before filling the container.

Electrodes. 6. The material shall be tested between hemispherical electrodes embedded therein which are $\frac{1}{2}$ in. in diameter separated by a gap of 0.1 in.

NOTE.—A convenient form of apparatus for holding the electrodes and compound is described in the Appendix.

Testing Transformer, Voltage Control and Measurement. 7. The testing transformer used, methods of voltage control and measurement shall be as outlined in Section 2 of the Tentative Method of Test for Dielectric Strength of Sheet and Tape Insulating Materials Under Momentary Dielectric Stress (Serial Designation: D 149 - 23 T) of the American Society for Testing Materials.[2]

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[1] 1921 Book of A. S. T. M. Standards.

[2] See p. 817.

Number of Specimens. 8. Five specimens at a given temperature shall be tested and the average value taken as the momentary dielectric strength of the compound at that temperature.

Report. 9. The report shall include the following:

(*a*) The momentary dielectric strength – temperature curve;

(*b*) The individual values of the puncturing voltage at the various temperatures.

APPENDIX

Because of the great difficulty in removing most cable splicing and pothead compounds from the container and from the electrodes, an arrangement was devised sufficiently inexpensive to permit of its being discarded wholly or in part after the test. That is, each specimen with its container can be entirely discarded without undue expense.

One form of container consists of a small rectangular box about 2½ in. (6.4 cm.) in length and 1½ in. (3.8 cm.) square, the ends of which are dry wood about ¼ in. in thickness. The sides and bottom are formed from a piece of thin, hard fiber tacked to the wooden end pieces. The fiber is partially cut at the corners which permits making a sharp, square bend.

Each electrode is mounted on the end of a piece of straight copper wire, No. 10 A.W.G., which passes through a hole at the center of the wooden end pieces. These holes are drilled in one operation so that they are in the same straight line. They are made slightly smaller so that the rods fit tightly and are therefore not readily moved.

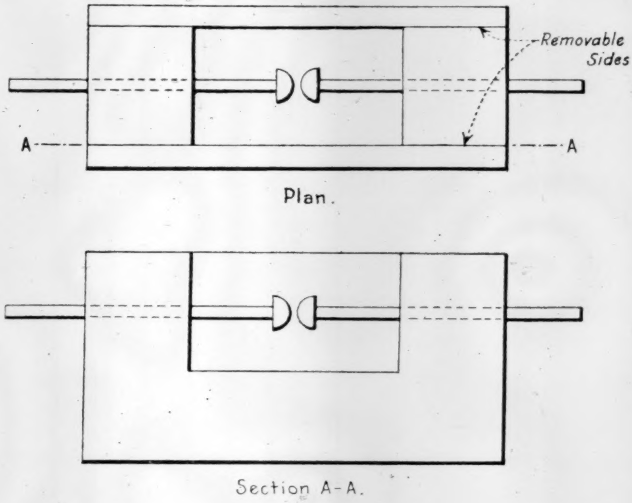

FIG. 1.—Container, Showing Electrodes in Place for Dielectric Test of Cable Splicing and Pothead Compounds.

Fig. 1 shows a sketch of a container in which the ends and the bottom are formed from one block of thoroughly dried wood which has been boiled in paraffin, the sides being pieces of thin, hard fiber tacked to the wood.

In the construction of these containers, it is obviously important that the electrodes be reasonably co-axial and that the gap remain constant.

In making tests at high voltage it will probably be found necessary to immerse the container with its specimen in oil in order to prevent flash-over between the exposed ends of the electrode rods. The ends of the rods can be bent to form hooks, by means of which the specimen holder can be readily suspended in a jar of oil.

TENTATIVE SPECIFICATIONS

FOR

WRAPPED AIR HOSE FOR USE WITH PNEUMATIC TOOLS.[1]

Serial Designation: D 46 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Material Covered.

1. These specifications cover wrapped air hose for use with pneumatic drills, hammers, hoists and other devices working at not more than 125-lb. pressure and for vacuum cleaning outfits.

I. MANUFACTURE.

Construction.

2. The hose shall consist of:

(*a*) An inner rubber tube;

(*b*) Reinforcement of plies of cotton duck;

(*c*) An outer rubber cover;

(*d*) A protective covering of wire armor or a woven cotton jacket when specified.

Rubber Tube.

3. The rubber tube shall be smooth, uniform in quality and thickness, and free from injurious defects.

Cotton Reinforcement.

4. (*a*) The reinforcement shall consist of plies of cotton duck cut on a bias of approximately 45 deg., and applied evenly and firmly over the tube with not less than a ½-in. lap. The number of plies shall be as specified in Table I. The plies of duck shall be well frictioned on both sides with a rubber compound which shall firmly join the plies to the rubber tube and cover and to each other.

(*b*) The cotton shall be as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice.

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[1] These Tentative Specifications are in effect a revision of the Standard Specifications for Air-Line Hose for Pneumatic Tools. The Standard Specifications, which were last published under the Serial Designation: D 46–18, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

(*c*) The reinforcement shall be sufficiently strong to enable the hose to successfully withstand the hydrostatic pressure test and yet at the same time be soft and pliable.

TABLE I.—NUMBER OF PLIES.

INSIDE DIAMETER OF HOSE, IN.	NUMBER OF PLIES.
$\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$	4
1, $1\frac{1}{8}$, $1\frac{1}{4}$, $1\frac{1}{2}$	5

Rubber Cover. 5. The rubber cover shall be uniform in quality and thickness' and be free from injurious defects.

Extra Coverings. 6. The extra coverings of wire armor or woven cotton jacket when specified shall be as follows:

(*a*) For hose 1 in. or less in diameter, the wire armor shall be $\frac{5}{32}$ by $\frac{1}{16}$-in. half-elliptical, galvanized mild steel wire wrapped with a maximum space of $\frac{3}{8}$ in. between adjacent turns. For hose over 1 in. in diameter, the wire armor shall be $\frac{3}{16}$ by $\frac{3}{32}$-in. half-round, galvanized mild steel wire wrapped with a maximum space of $\frac{3}{8}$ in. between adjacent turns. Any other size of half-elliptical or half-round wire of equal or greater area may be used provided neither dimension varies more than $\frac{1}{64}$ in. from that specified above.

(*b*) The weight of the woven cotton jacket per linear foot shall be not less than the following:

SIZE OF HOSE, IN.	MINIMUM WEIGHT, OZ. PER LIN. FT.
$\frac{3}{8}$	$\frac{3}{4}$
$\frac{7}{16}$	$\frac{7}{8}$
$\frac{1}{2}$	1
$\frac{5}{8}$	$1\frac{1}{4}$
$\frac{3}{4}$	$1\frac{1}{2}$
1	2
$1\frac{1}{8}$	$2\frac{1}{4}$
$1\frac{1}{4}$	$2\frac{1}{2}$
$1\frac{1}{2}$	3

II. PHYSICAL PROPERTIES AND TESTS.

Standard Methods. 7. The tests necessary to determine the physical properties which are prescribed in the following sections shall be made in accordance with the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 23 T) of the American Society for Testing Materials.[1]

Test Sample. 8. A sample 36 in. in length shall be cut from each lot of 500 ft. of hose or less and subjected to the following tests.

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[1] See p. 870.

Tests of Tube and Cover. 9. (*a*) In the case of hose 1 in. or less in diameter the test specimens shall be cut longitudinally from the sample of the hose; in the case of hose over 1 in. in diameter the test specimens shall be cut transversely.

(*b*) The tensile strength shall be not less than 800 lb. per sq. in. for the tube and 1000 lb. per sq. in. for the cover.

(*c*) The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimens shall stretch to not less than 7 in. in the case of the tube and 9 in. in the case of the cover.

(*d*) The set, or permanent elongation, following a stretch from 2 in. to 5 in. in the case of the tube and from 2 in. to 7 in. in the case of the cover shall not exceed 25 per cent.

Friction Test. 10. The adhesion between plies shall be such that a weight of 18 lb. will not cause separation at a rate greater than 1 in. per minute.

TABLE II.—TEST PRESSURES.

INSIDE DIAMETER OF HOSE, IN.	TEST PRESSURE, LB. PER SQ. IN.
3/8	700
7/16	675
1/2	650
5/8	625
3/4	625
1	600
1 1/8	575
1 1/4	575
1 1/2	550

The adhesion between the cover and plies and also between the tube and the plies shall be such that a weight of 15 lb. will not cause separation at a rate greater than 1 in. per minute.

Hydrostatic Pressure Tests. 11. From the 36-in. sample, a piece of hose 24 in. in length shall be taken and subjected to a hydrostatic test at the pressure specified in Table II for hose of its size.

The test shall continue for five minutes and the hose shall withstand the pressure without bursting or developing leaks or other defects. The wire protective covering shall be removed from protected hose prior to this test.

On large orders the number of tests may be reduced to not less than three at the option of the inspector representing the purchaser.

III. STANDARD SIZES AND DIMENSIONS.

Length. 12. Unless otherwise specified, the hose shall be furnished in 50-ft. lengths. The ends of each length shall be uncapped and without fittings.

13. The minimum thicknesses shall be $\frac{3}{32}$ in. for the rubber tube and $\frac{1}{16}$ in. for the rubber cover. **Size and Thickness.**

14. The inside diameter shall vary not more than $\pm\frac{1}{64}$ in. from that specified in the case of $\frac{3}{8}$ to $\frac{3}{4}$-in. hose, inclusive, nor more than $\pm\frac{1}{32}$ in. from that specified for larger sizes. **Tolerances, Inside Diameter.**

IV. MARKING.

15. Each 50-ft. length of hose shall have inlaid in the rubber cover in three places, namely, midway between the ends and within 10 ft. of each end, a brand showing the name of the manufacturer, the month and year of manufacture, the trade name of the hose, and the legend "Wrapped-Air 125 lb. A.S.T.M. Specifications." The letters and figures shall be $\frac{1}{4}$ in. high, shall stand $\frac{1}{32}$ in. in relief, and shall be clear and distinct. **Marking.**

V. INSPECTION AND REJECTION.

16. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangement for inspection. **Inspection.**

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. But such tests shall be made within 60 days after date of shipment and at the expense of the purchaser.

17. (*a*) Each length of hose that fails to meet any of the requirements of these specifications shall be rejected. **Rejection.**

(*b*) In the case of failure to pass any one of the tests specified in Sections 9, 10, and 11, the entire lot of hose represented by the sample, or samples, subjected to these tests shall be rejected.

18. Samples of rejected hose shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the test, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

TENTATIVE SPECIFICATIONS
FOR
BRAIDED AIR HOSE FOR USE WITH PNEUMATIC TOOLS.[1]

Serial Designation: D 60 – 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Material Covered. 1. These specifications cover braided air hose for use with pneumatic hammers, drills, hoists and other devices working at not more than 125-lb. pressure, and for vacuum cleaning outfits.

I. MANUFACTURE.

Construction. 2. The hose shall consist of:

(*a*) An inner rubber tube;

(*b*) Reinforcement of plies of braided cotton;

(*c*) An outer rubber cover;

(*d*) A protective covering of wire armor or a woven cotton jacket when specified.

Rubber Tube. 3. The rubber tube shall be smooth, uniform in quality and thickness, and free from injurious defects.

Cotton Reinforcement. 4. (*a*) The reinforcement shall consist of three plies of braided cotton evenly and firmly woven over the rubber tube. The plies of braid shall be well impregnated with a rubber compound which shall firmly join the plies to the rubber tube and rubber cover and to each other. There shall be a sufficient coating of rubber compound between the plies so as to form a distinct layer of rubber.

(*b*) The cotton shall be as free from unsightly defects, dirt, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice.

(*c*) The reinforcement shall be sufficiently strong to enable the hose to successfully withstand the hydrostatic pressure test, yet at the same time be soft and pliable.

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[1] These Tentative Specifications are in effect a revision of the Standard Specifications for Leader Hose for Use with Pneumatic Tools. The Standard Specifications, which were last published under the Serial Designation: D 60–20, have accordingly been withdrawn.

Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

Rubber Cover. 5. The rubber cover shall be uniform in quality and thickness, and free from injurious defects.

Extra Coverings. 6. When extra coverings of wire armor or braided cotton are specified, they shall be applied as follows:

(*a*) For hose 1 in. or less in diameter, the wire armor shall be $\frac{5}{32}$ by $\frac{1}{16}$-in. half-elliptical, galvanized mild steel wire wrapped with a maximum space of $\frac{3}{8}$ in. between adjacent turns. For hose over 1 in. in diameter, the wire armor shall be $\frac{3}{16}$ by $\frac{3}{32}$-in. half-round, galvanized mild steel wire wrapped with a maximum space of $\frac{3}{8}$ in. between adjacent turns. Any other size of half-elliptical or half-round wire of equal or greater area may be used provided neither dimension varies more than $\frac{1}{64}$ in. from that specified above.

(*b*) The weight of the woven cotton jacket per linear foot shall be not less than the following values:

SIZE OF HOSE, IN.	MINIMUM WEIGHT, OZ. PER LIN. FT.
$\frac{3}{8}$	$\frac{3}{4}$
$\frac{7}{16}$	$\frac{7}{8}$
$\frac{1}{2}$	1
$\frac{5}{8}$	$1\frac{1}{4}$
$\frac{3}{4}$	$1\frac{1}{2}$
1	2
$1\frac{1}{8}$	$2\frac{1}{4}$
$1\frac{1}{4}$	$2\frac{1}{2}$
$1\frac{1}{2}$	3

II. PHYSICAL PROPERTIES AND TESTS.

Standard Methods. 7. The tests necessary to determine the physical properties which are prescribed in the following sections shall be made in accordance with the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 23 T) of the American Society for Testing Materials.[1]

Test Sample. 8. A sample 36 in. in length shall be cut from each lot of 500 ft. of hose or less and subjected to the following tests.

Tests of Tube and Cover. 9. (*a*) In the case of hose 1 in. or less in diameter, the test specimens shall be cut longitudinally from the sample of the hose; in the case of hose over 1 in. in diameter, the test specimens shall be cut transversely.

(*b*) The tensile strength shall be not less than 800 lb. per sq. in. for the tube of 1000 lb. per sq. in for the cover.

(*c*) The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimens shall stretch to not less than 7 in. in the case of the tube and 9 in. in the case of the cover.

---

[1] See p. 870.

(*d*) The set, or permanent elongation following a stretch from 2 in. to 5 in. in the case of the tube and from 2 in. to 7 in. in the case of the cover shall not exceed 25 per cent.

Friction Test.

10. The adhesion between plies shall be such that a weight of 18 lb. will not cause separation at a rate greater than 1 in. per minute. The adhesion between the cover and plies and also between the tube and the plies shall be such that a weight of 15 lb. will not cause separation at a rate greater than 1 in. per minute.

Hydrostatic Test.

11. From the 36-in. sample described in Section 8, a piece of hose 24 in. in length shall be taken and subjected to a hydrostatic test at the pressure specified in Table I for hose of its size.

The test shall continue for five minutes and the hose shall withstand the pressure without bursting or developing leaks or other defects. The protective covering shall be removed from protected hose prior to this test.

On large orders the number of tests may be reduced to not less than three at the option of the inspector representing the purchaser.

TABLE I.—TEST PRESSURES.

INSIDE DIAMETER OF HOSE, IN.	TEST PRESSURE, LB. PER SQ. IN.
$\frac{3}{8}$	800
$\frac{7}{16}$	800
$\frac{1}{2}$	800
$\frac{5}{8}$	800
$\frac{3}{4}$	800
1	700
$1\frac{1}{8}$	650
$1\frac{1}{4}$	600
$1\frac{1}{2}$	550

III. STANDARD DIMENSIONS AND WEIGHTS.

Length.

12. Unless otherwise specified, the hose shall be furnished in 50-ft. lengths. The ends of each length shall be uncapped and without fittings.

Thickness.

13. (*a*) The minimum thickness for the tube of $\frac{3}{8}$ and $\frac{7}{16}$-in. hose shall be 0.045 in.; for $\frac{1}{2}$ to $\frac{3}{4}$-in. hose, inclusive, the minimum thickness for the tube shall be 0.062 in., and for 1 to $1\frac{1}{2}$-in. hose, inclusive, the minimum thickness of the tube shall be 0.094 in. The minimum thickness for the cover of $\frac{3}{8}$ and $\frac{7}{16}$-in. hose shall be 0.045 in.; for $\frac{1}{2}$ to $1\frac{1}{2}$-in. hose, inclusive, the minimum thickness of the cover shall be 0.062 in.

(*b*) The gage of the tube and cover shall be measured with the braid embedded in the rubber.

14. The inside diameter shall vary not more than $\pm \frac{1}{32}$ in. from that specified in the case of $\frac{3}{8}$ to $\frac{3}{4}$-in. hose, inclusive, nor more than $\pm \frac{1}{16}$ in. from that specified for larger sizes. **Tolerances.**

IV. MARKING.

15. Each 50-ft. length of hose shall have inlaid in the rubber cover in three places, namely, midway between the ends and within 10 ft. of each end, a brand showing the name of the manufacturer, the month and year of manufacture, the trade name of the hose and the legend "Braided-Air 125 lb. A.S.T.M. Specifications." The letters and figures shall be $\frac{1}{4}$ in. high, shall stand $\frac{1}{32}$ in. in relief, and shall be clear and distinct. **Marking.**

V. INSPECTION AND REJECTION.

16. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangement for inspection. **Inspection.**

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. Such tests shall be made within 60 days after date of shipment and at the expense of the purchaser.

17. (*a*) Each length of hose that fails to meet any of the requirements of these specifications shall be rejected. **Rejection.**

(*b*) In the case of failure to pass any one of the tests specified in Sections 9, 10, and 11, the entire lot of hose represented by the sample, or samples, subjected to these tests shall be rejected.

18. Samples of rejected hose shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

TENTATIVE SPECIFICATIONS
FOR
RUBBER BELTING FOR POWER TRANSMISSION.[1]

Serial Designation: D 53 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

Material Covered.

1. These specifications cover two classes of rubber belting for power transmission:

(*a*) *Friction Covered.*—Possessing no distinct rubber cover other than that imparted to the cotton duck by the regular rubber frictioning process.

(*b*) *Rubber-Covered.*—Possessing a distinct rubber cover over the outside plies of rubber-frictioned cotton duck and extending around the edges.

I. MANUFACTURE.

Construction.

2. The belting shall consist of:

(*a*) Cotton duck reinforcement;

(*b*) Rubber friction compound;

(*c*) An outside rubber cover, when specified.

Reinforcement.

3. The reinforcement shall consist of plies of cotton duck evenly and firmly woven, as free from such defects as foreign matter, knots, lumps and irregularities of twist as is consistent with the best manufacturing practice. Each ply shall be well frictioned on both sides with a rubber compound suitable for the required service.

Rubber Beading.

4. The seam in the outside ply of the belting shall be completely filled with a rubber cord, or "beading," well fastened down with a rubber cover-strip.

Rubber Cover.

5. When rubber-covered belting is specified, the rubber cover shall be uniform in thickness and free from cracks, blisters or other defects which would impair its moisture-resisting qualities.

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[1] These Tentative Specifications are in effect a revision of the Standard Specifications for Rubber Belting for Power Transmission. The Standard Specifications, which were last published under the Serial Designation: D 53 - 20, have accordingly been withdrawn

Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1924, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

II. PHYSICAL PROPERTIES AND TESTS.

Temperature of Testing Room and Samples.

6. Tests shall be made with the temperature of the air not lower than 65° F. or higher than 90° F., and the samples shall be kept at temperatures within these limits for at least 30 minutes previous to the time of test.

Sampling.

7. One sample, the full width of the belt, shall be taken from each lot of 500 ft. or less. This sample shall be 26 in. in length for all widths 6 in. and over, and 32 in. for widths under 6 in.

Number of Tests.

8. One friction test, one stretch test, one tension test, one beading test and three filler strength tests shall be made upon the sample described in Section 7.

Test Specimens.

9. Friction specimens may be taken either longitudinally or transversely of the sample of belting. Stretch and tension test specimens shall be the full width and thickness of the belting up to and including 5 in. For widths greater than 5 in. the test specimen shall be cut to a width of 5 in., parallel to an edge and beginning ½ in. from one of the edges of the belting.

Friction Test.

10. (*a*) Tests to determine the adhesion between plies shall be made in accordance with the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 - 23 T) of the American Society for Testing Materials.[1]

(*b*) The adhesion between the plies shall be such that a weight of 20 lb. will not cause separation at a rate greater than 1 in. per minute.

Stretch Test of Belting.

11. A test specimen 20 in. in length and prepared as described in Section 9 shall have transverse reference lines marked upon it 10 in. apart and at equal distances from the ends; it shall then be tested in a tension testing machine and under a pull of 100 lb. per in. per ply, shall stretch not more than 9 per cent nor less than 5 per cent. The rate of separation of the jaws shall be approximately 1½ in. to 4 in. per minute.

Tension Test.

12. The stretch test described in Section 11 shall be continued to the breaking point in order to obtain the ultimate tensile strength which shall be not less than 260 lb. per in. per ply.

Test of Beading.

13. The beading in all belting 4 in. wide or over shall be tested as follows: A 4-in. transverse section of belting shall be taken and beginning on the seamless side, the plies shall be removed until three only remain intact. A line shall be drawn down the middle of the beading and then on each side of this line, and ⅝ in. distant from it, two parallel lines shall be scribed. The section shall be inserted in a vise so that the jaws grip the sample coincident with the two outer

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[1] See p. 870.

lines. The vise shall be tightened until the inner surfaces of the doubled sample just touch at the top of the vise, and the sample shall be so held for 10 minutes. Under this test the beading shall not crack or loosen in the seam.

Test of Filler Strength of Duck.

14. The filler or weft strength of the cotton duck in the belting shall be determined as follows: A transverse strip $1\frac{1}{2}$ in. wide shall be cut from the belting and separated into its various plies. Three of these plies shall be ravelled down to a width of 1 in. and tested in a fabric testing machine, the minimum width of jaws of which is $1\frac{1}{2}$ in., the distance between jaws 3 in. and the speed of separation of jaws approximately 20 in. per minute. The tensile strength shall be at least 175 lb.

III. DIMENSIONS.

Width of Belting.

15. The width of the belting shall conform to that specified within the following tolerances:

WIDTH.	PERMISSIBLE PLUS OR MINUS VARIATIONS, IN.
Up to 12 in., inclusive	$\frac{3}{16}$
Over 12 in. to 24 in., inclusive	$\frac{1}{4}$
Over 24 in.	$\frac{5}{16}$

Thickness of Belting.

16. The thickness of the belting in inches shall be not less than 0.050 multiplied by the number of plies, plus the thickness of the rubber covers, if any.

Thickness of Cover.

17. The cover (Section 1 (*b*)) shall be not less than $\frac{3}{128}$ (=0.023) in. in thickness. This shall also apply to the edges.

IV. MARKING.

Marking.

18. Belting 4 in. wide or over shall have the name of the manufacturer, the month and year of manufacture, the trade name of the belt, and the legend "Power A.S.T.M. Specifications" impressed in the strip side at points not more than 15 ft. apart. For widths under 4 in. this information shall be stencilled on the belting.

Endless Belts.

19. Endless belts shall have marks showing in which direction the belt shall be run with regard to the splices.

V. INSPECTION AND REJECTION.

Inspection.

20. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the belting to permit of arrangement for inspection.

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the belting is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the belting in his own laboratory or elsewhere. Such tests shall be made within 60 days after date of shipment at the expense of the purchaser.

Rejection. 21. Any length of belting which fails to meet the requirements of these specifications shall be rejected.

Rehearing. 22. Samples of rejected belting shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
WRAPPED COLD WATER HOSE[1]

Serial Designation: D 177 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Material Covered. 1. These specifications cover hose for use in conveying cold water for other than public or private fire department use.

I. MANUFACTURE

Construction. 2. The hose shall consist of:

(*a*) An inner rubber tube;

(*b*) Reinforcement of plies of cotton duck;

(*c*) An outer rubber cover.

Rubber Tube. 3. The rubber tube shall be smooth, uniform in quality and thickness and free from injurious defects.

Cotton Reinforcement. 4. (*a*) The reinforcement shall consist of plies of cotton duck cut on a bias of approximately 45 deg., and applied evenly and firmly over the tube with not less than a $\frac{1}{2}$-in. lap, not sewed. The number of plies shall be as follows:

Inside Diameter of Hose, in.	Number of Plies
$\frac{1}{2}$, $\frac{3}{4}$	3
1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, $2\frac{1}{4}$	4
$2\frac{1}{2}$ to 4	5

The plies of duck shall be well frictioned on both sides with a rubber compound which shall firmly join the plies to the rubber tube and cover and to each other.

(*b*) The duck shall be evenly woven from high grade cotton and shall be free from mechanical defects.

(*c*) The reinforcement shall be sufficiently strong to enable the hose to successfully withstand the hydrostatic pressure test and yet at the same time be soft and pliable.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

Rubber Cover. 5. The rubber cover shall be uniform in quality and thickness, and be free from injurious defects.

II. PHYSICAL PROPERTIES AND TESTS

Standard Methods. 6. The tests necessary to determine the physical properties prescribed in the following sections shall be made in accordance with the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 23 T) of the American Society for Testing Materials.[1]

Test Sample. 7. A sample 36 in. in length shall be cut from each lot of 500 ft. or fraction thereof of each size of hose.

Tests of Tube and Cover. 8. (*a*) In the case of hose 1 in. or less in diameter, the test specimens shall be cut longitudinally from the sample of the hose; in the case of hose over 1 in. in diameter, the test specimens shall be cut transversely.

(*b*) The tensile strength shall be not less than 600 lb. per sq. in. for the tube and 450 lb. per sq. in. for the cover.

(*c*) The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimens shall stretch to not less than 8 in. in the case of the tube and 6 in. in the case of the cover.

(*d*) The set or permanent elongation following a stretch from 2 in. to 6 in. in the case of the tube and from 2 in. to 4 in. in the case of the cover shall not exceed 25 per cent.

Friction Test. 9. The adhesion between plies shall be such that a weight of 15 lb. will not cause separation at a rate greater than 1 in. per minute. The adhesion between the cover and the plies, and also between the tube and the plies shall be such that a weight of 12 lb. will not cause separation at a rate greater than 1 in. per minute.

Hydrostatic Pressure Test. 10. The remainder of the 36-in. sample after all other test specimens have been cut therefrom shall withstand a hydrostatic pressure test as follows:

INSIDE DIAMETER OF HOSE, IN.	TEST PRESSURE, LB. PER SQ. IN.
$\frac{1}{2}$, $\frac{3}{4}$	450
1, $1\frac{1}{4}$, $1\frac{1}{2}$	350
2, $2\frac{1}{4}$, $2\frac{1}{2}$	300
3, $3\frac{1}{2}$ and 4	250

III. STANDARD SIZES AND DIMENSIONS

Length. 11. Unless otherwise specified, the hose shall be furnished in 50-ft. lengths. The ends of each length shall be uncapped and without fittings.

Thickness of Tube and Cover. 12. The minimum thickness for the tube of all sizes of hose shall be 0.062 in. The minimum thickness for the cover for $\frac{1}{2}$ and $\frac{3}{4}$-in.

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[1] See p. 870.

hose shall be 0.031 in. and for all other sizes of hose, the minimum thickness for the cover shall be 0.047 in.

Inside Diameter. 13. The inside diameter shall not vary more than ± $\frac{1}{64}$ in. from that specified for $\frac{1}{2}$ and $\frac{3}{4}$-in. hose, nor more than ± $\frac{1}{32}$ in. from that specified for all other sizes.

IV. MARKING

Marking. 14. Each length of hose 25 ft. or over in length shall have a brand inlaid in the rubber cover in three places: namely, approximately in the center and approximately 5 ft. from each end. Each length of less than 25 ft. shall have a brand inlaid approximately in the center. The brand shall show the name of the manufacturer, the kind and size of hose, the month and year of manufacture, the trade name of the hose, and the legend "Wrapped Cold Water, ... lb., A.S.T.M. Specifications." The letters and figures shall be $\frac{1}{4}$ in. high, $\frac{1}{32}$ in. in relief and shall be clear and distinct.

V. INSPECTION AND REJECTION

Inspection. 15. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the hose to permit of arrangement for inspection.

(*b*) The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the hose is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the hose in his own laboratory or elsewhere. But such tests shall be made within 60 days after date of shipment and at the expense of the purchaser.

Rejection. 16. (*a*) Any length which fails to meet any of the requirements of these specifications shall be rejected.

(*b*) In the case of failure to pass any one of the tests specified in Sections 8, 9 and 10, the entire lot of hose represented by the sample, or samples, subjected to these tests shall be rejected.

Rehearing. 17. Samples of rejected hose shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the test, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
RUBBER MATTING FOR USE AROUND ELECTRICAL APPARATUS OR CIRCUITS NOT EXCEEDING 3000 VOLTS TO GROUND[1]

Serial Designation: D 178 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

SPECIFICATIONS

Material Covered. 1. These specifications cover rubber matting for use as a floor covering near electrical apparatus.

I. MANUFACTURE

Construction. 2. The matting shall consist of a rubber compound corrugated on one surface and backed with cotton fabric, or having one or more cotton fabric inserts, the back of the matting being finished with cloth imprint.

II. PHYSICAL PROPERTIES AND TESTS

(*A*) *Mechanical*

Methods. 3. All the tests necessary to determine the mechanical properties specified in the following sections shall be made on the rubber exclusive of fabric and shall be made in accordance with Sections 48 to 56, inclusive, of the Tentative Methods of Testing Rubber Products (Serial Designation: D 15 – 23 T) of the American Society for Testing Materials.[2]

Sampling. 4. Not less than one sample shall be taken from each piece or roll of matting and subjected to the following tests.

Tensile Strength, Elongation and Set. 5. (*a*) The tensile strength shall be not less than 700 lb. per sq. in.

(*b*) The elongation at the breaking load shall be such that the original 2-in. gage length of the test specimens shall stretch to not less than 7 in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

[2] See p. 870.

(*c*) The set, following a stretch from 2 in. to 5 in., shall not exceed 25 per cent.

(*B*) *Electrical*

Methods. 6. All the tests necessary to determine the electrical properties specified in the following sections shall be made in accordance with the methods described in Sections 13 to 17, inclusive.

Voltage Test. 7. (*a*) The entire area of the matting as nearly as practicable shall be tested between electrodes consisting of rectangular metal sheets, having smoothly rounded edges and corners and of any convenient length, the width being such that arcing around the edges of the matting will not occur, the tests being made progressively until the entire length of the matting has been covered.

(*b*) A potential of 15,000 volts shall be applied for one minute at each position of the electrodes. The matting shall not puncture, become appreciably warm at any spot or show any other sign of weakness.

Dielectric Strength Test. 8. A specimen cut from the sample and tested to failure in air between 2-in. disk electrodes with edges rounded to a radius of $\frac{1}{4}$ in., the voltage being applied at the rate specified in Section 14, shall not fail at less than 40,000 volts.

III. DIMENSIONS

Thickness 9. The thickness, unless otherwise specified, shall be not less than $\frac{1}{4}$ in. when measured over the corrugations and not less than $\frac{1}{8}$ in. at the root of the corrugations.

IV. WORKMANSHIP AND FINISH

Surface Defects. 10. Matting shall be free from patches, blisters, pin-holes, cracks, protuberances, embedded foreign matter or other physical defects which can be detected by thorough surface inspection.

V. INSPECTION AND REJECTION

Inspection. 11. The matting shall be inspected and tested within four weeks of the date of delivery.

Rejection. 12. (*a*) Any piece or roll of matting which fails to pass any of the requirements of these specifications shall be rejected.

(*b*) In case of failure to pass any one of the tests specified in Sections 5 and 8, the piece or roll of matting represented by the sample subjected to these tests shall be rejected.

METHODS OF TESTING

Source of Test Voltage.

13. The testing voltage shall be obtained from a testing equipment, no part of which has a capacity of less than $\frac{1}{2}$ kva. per sq. ft. of electrode surface. In no case shall the rating of any part of the testing apparatus be less than 5 kva. The frequency of the testing voltage shall be not more than 65 cycles.

Application of Test Voltage.

14. The potential shall be applied at a low value and gradually and steadily raised at a rate of approximately 800 to 1000 volts per second until the prescribed testing voltage is reached.

Test Period.

15. The test period shall be counted from the instant when the prescribed testing voltage is reached.

Voltage Regulation.

16. The method of regulating the testing voltage shall be one which does not distort the wave form of the testing voltage from a sine wave. Acceptable methods include:

(*a*) Field regulation of the alternator supplying the transformer;

(*b*) Induction-type regulator;

(*c*) Variable-ratio-transformer type of regulator;

(*d*) Potentiometer type of rheostatic control where the current in the portion of the potentiometer resistance in parallel with the primary of the transformer is at least five times the exciting current of the transformer.

Voltage Measurement.

17. The testing voltage shall be measured by one of the following methods:

(*a*) A properly calibrated electrostatic voltmeter connected directly across the matting under test.

(*b*) Any properly calibrated commercial type of alternating current voltmeter connected to the low tension side of the transformer in conjunction with the ratio of transformation of the transformer provided that the ratio is definitely known for all test conditions.

(*c*) A calibrated potential transformer with a voltmeter.

TENTATIVE METHODS OF TESTING RUBBER PRODUCTS.[1]

Serial Designation: D 15 - 23 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1922; REVISED, 1923.

I. CHEMICAL TESTS

(*A*) *Short Procedure.*

I. GENERAL INSTRUCTIONS.

Blanks. 1. Blank tests shall be run on all determinations and deductions made accordingly.

Checks. 2. In the event of any determination not falling within the limits given in these methods of test, a duplicate determination which shall agree within the limits specified shall be made and the average value taken as the true value.

Preparation of Specimen. 3. (*a*) A specimen weighing not less than 15 g. shall be prepared, taking pieces from various parts of the sample.

(*b*) The specimen shall be cut into small pieces and run through a grinder until all of it will pass through a 20-mesh sieve. Care must be taken that the grinder does not become appreciably warm. The backing shall be buffed off before grinding.

Removal of Iron and Care of Specimen. 4. A strong magnet shall be passed through the specimen to remove any metal from the grinder, and the specimen shall be mixed thoroughly and put in tightly stoppered bottles. It shall not be exposed to sunlight or heat.

II. REAGENTS.

Acetone. 5. Acetone shall be distilled not more than 10 days before use over anhydrous potassium carbonate, using the fraction which distills at 56 to 57° C.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1924, to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

These tentative methods, when adopted as standard, will supersede the present Standard Methods of Testing Cotton Rubber-Lined Hose (Serial Designation: D 15 – 15), 1921 Book of A.S.T.M. Standards.

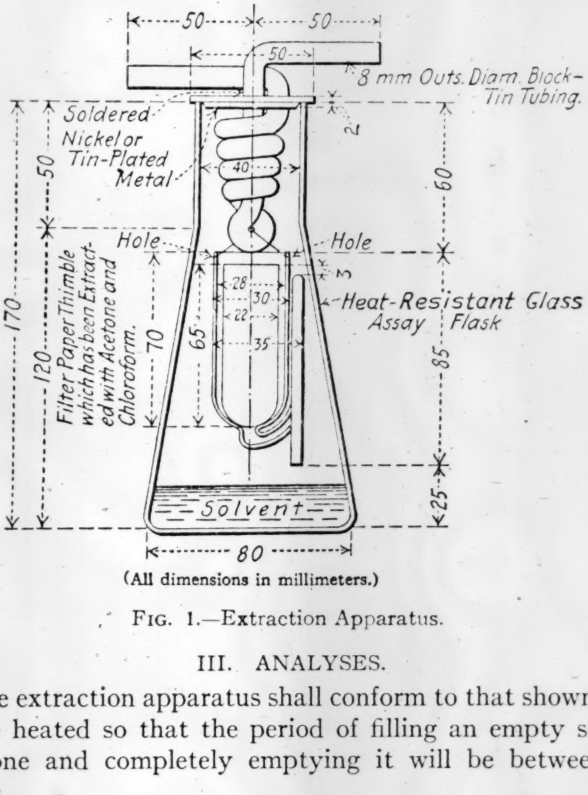
Alcoholic Potash.

6. Alcoholic potash shall be of normal strength, made by dissolving the required amount of KOH in absolute alcohol the day before use, and allowing to settle. Only the clear solution shall be used.

Barium-Chloride Solution.

7. Barium-chloride solution shall be made by dissolving 100 g. of crystallized barium chloride in one liter of distilled water and adding two or three drops of concentrated hydrochloric acid. If there is any insoluble matter or cloudiness, the solution shall be heated on the steam bath over night and filtered.

All reagents shall be of a purity equal to that called for in Krauch's "Standard Chemical Reagents; their Purity and Test."


50
50
50
8 mm Outs. Diam. Block-Tin Tubing.
2
Soldered Nickel or Tin-Plated Metal
50
40
60
Hole
Hole
3
28
30
22
35
Heat-Resistant Glass Assay Flask
170
120
Filter Paper Thimble which has been Extracted with Acetone and Chloroform.
70
65
85
25
Solvent
80

(All dimensions in millimeters.)

FIG. 1.—Extraction Apparatus.

III. ANALYSES.

Acetone Extract.

8. The extraction apparatus shall conform to that shown in Fig. 1. It shall be heated so that the period of filling an empty siphon cup with acetone and completely emptying it will be between 2½ and 3½ minutes.

Two grams of the rubber shall be extracted continuously with acetone for 8 hours, using a sample that has been prepared within 24 hours. Distill off the acetone and dry the flask and contents for 4 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down from the side of the flask.

Free Sulfur.

9. Add to the flask containing the acetone extract 50 to 60 cc. of distilled water and 2 or 3 cc. of bromine (if the acetone extract indicates a large amount of free sulfur, the amount of bromine should be increased). Heat gently on the steam bath until the solution is practically colorless and filter into a 400-cc. beaker. Dilute with distilled water until the volume is about 400 cc. Cover the beaker with a watch glass, heat to boiling on the steam bath, add 10 cc. of 10-per-cent barium-chloride solution and allow the precipitate to stand over night. The next day filter off the precipitate, ignite the filter paper and weigh.

Alcoholic-Potash Extract.

10. Dry the residue from the acetone extraction at 50 to 60° C., put into a 200-cc. Erlenmeyer flask with 50 cc. of the alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution into a beaker and wash twice, using each time 25 cc. of hot absolute alcohol and then wash thoroughly with hot water. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. 5 *N* HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool, add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portion of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Total Sulfur.

11. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion. Then bring to quiet fusion for 15 to 20 minutes, applying heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and

dehydrate if silica is present; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 400 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent barium-chloride solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

Ash. 12. Weigh out a 1-g. sample in a porcelain crucible, heat in a muffle furnace, the temperature of which is carefully regulated so that no material amount of visible products are given off. After the mass is charred, the temperature shall be raised sufficiently to burn the carbon. The whole process shall be conducted at as low a temperature as possible. At the end of this operation the crucible shall be removed from the furnace, cooled in a desiccator and weighed; the ash broken up and inspected for carbon. If any visible carbon is present, a new determination shall be conducted.

IV. CALCULATIONS.

Calculations. 13. The percentage of rubber shall be considered to be the difference between 100 and the sum of the total sulfur and ash expressed as percentages and figured on the total compound. If the alcoholic-potash extract is over 2 per cent of the rubber as first calculated, subtract this excess also from the rubber. The organic-acetone extract shall be obtained by taking the difference between the total acetone extract and the free sulfur. The organic-acetone extract, free sulfur, total sulfur and alcoholic-potash extract shall be figured on the amount of gum as found by the above procedure.

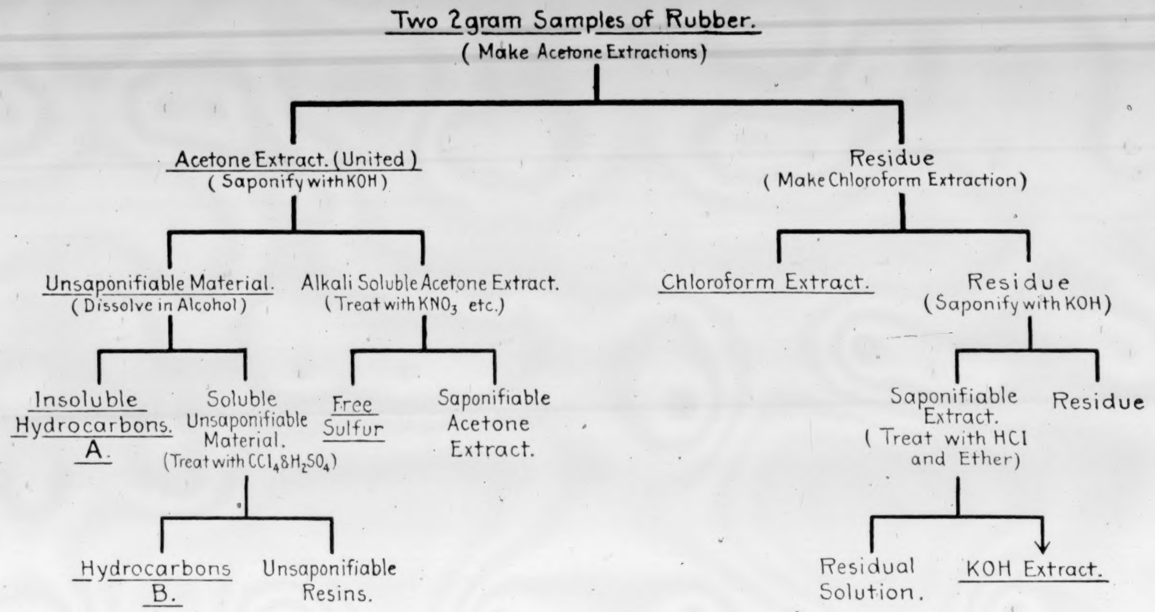
V. CHECK ANALYSES.

Check Analysis. 14. Duplicate determinations when required shall check within the following limits, expressed as percentages of the gum present, as found by analysis, except as stated.

	CHECK WITHIN, PER CENT.
Organic-acetone extract	0.10
Free sulfur	0.10
Total sulfur	0.10
Alcoholic-potash extract	0.10
Ash calculated on total compound	0.25

(B) *Complete Procedure.*

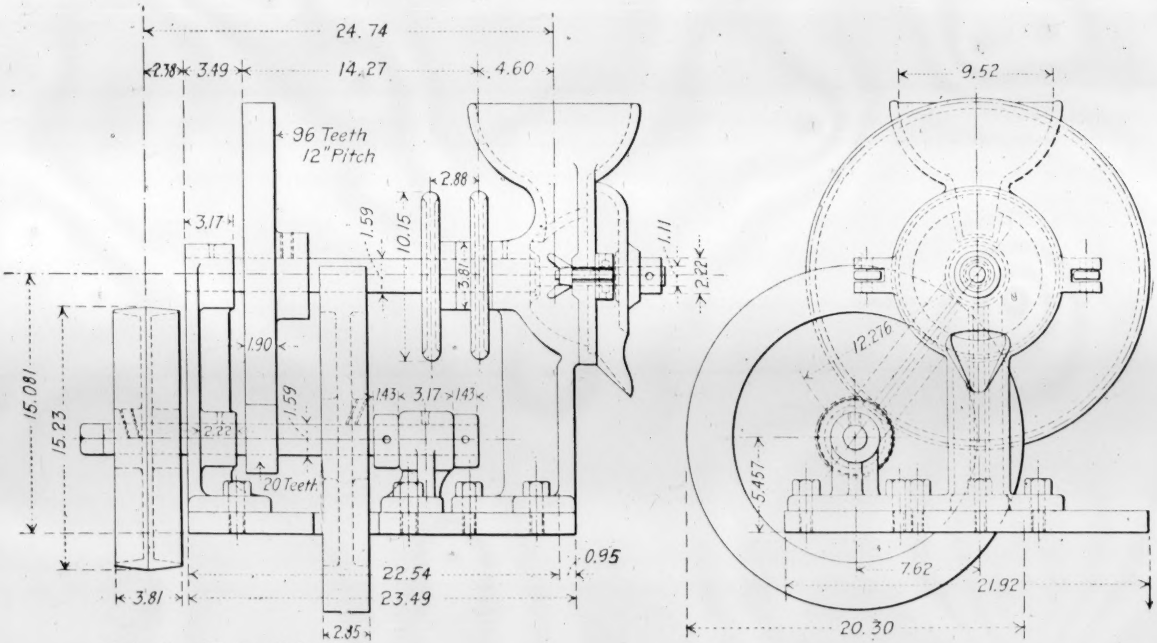
NOTE.—The following is the procedure of the Joint Rubber Insulation Committee and was originally prepared for 30-per-cent Hevea rubber insulation for wires and cables. It is applicable to similar rubber compounds used for other


Two 2gram Samples of Rubber.
(Make Acetone Extractions)
Acetone Extract. (United)
(Saponify with KOH)
Residue
(Make Chloroform Extraction)
Unsaponifiable Material.
(Dissolve in Alcohol)
Alkali Soluble Acetone Extract.
(Treat with KNO$_3$ etc.)
Chloroform Extract.
Residue
(Saponify with KOH)
Insoluble Hydrocarbons. A.
Soluble Unsaponifiable Material.
(Treat with CCl$_4$ & H$_2$SO$_4$)
Free Sulfur
Saponifiable Acetone Extract.
Saponifiable Extract.
(Treat with HCl and Ether)
Residue
Hydrocarbons B.
Unsaponifiable Resins.
Residual Solution.
KOH Extract.

Total Waxy Hydrocarbons = A + B.

Weigh Substances with Names Underlined; Other Substances by Difference.

FIG. 2.—Outline of Method For Rubber Analysis.
(Exclusive of Fillers and Total Sulfur Determinations.)


24.74
2.38
3.49
14.27
4.60
96 Teeth
12" Pitch
3.17
2.88
1.59
10.15
3.81
1.11
2.22
1.90
1.43
3.17
1.43
15.081
15.23
2.22
1.59
20 Teeth
22.54
0.95
23.49
3.81
2.85
9.52
12.276
5.457
7.62
21.92
20.30

Grinding Plates of the No. 0
Enterprise Coffee Mill to be Used.

(All Dimensions in Centimeters.)

FIG. 3.—Diagram for Rubber Grinder.

purposes, but obviously in such cases the references in this procedure to insulation for wires and cables should be disregarded.

Object of Analysis. 15. The object of this procedure of analysis is to determine whether rubber compounds comply chemically with specifications which are intended to secure compounds containing 30 per cent of the best Hevea rubber, and mineral fillers.

Outline. 16. The general procedure is shown in Fig. 2.

VI. GENERAL INSTRUCTIONS.

Samples. 17. (*a*) The analysis shall be made upon the compound after vulcanization.

(*b*) In the case of insulation from wires and cables, samples for analysis shall be taken before the saturation of the braid whenever possible. The insulation shall be thoroughly wiped with a damp cloth to remove any adhering material but without removing waxy hydrocarbons from the surface.

(*c*) If a sample of insulation from wires and cables has to be taken after the braid has been saturated, the braid shall be removed and the insulation sand-papered to a depth of 0.005 in. and then wiped with a damp cloth. The condition of the sample shall be reported.

Duplicate Analyses. 18. All determinations shall be performed in duplicate and the average value taken arbitrarily as the true value. Duplicate determinations shall check within the limits specified.

Blanks. 19. Blanks shall be made on all determinations and the results deducted accordingly.

Preparation of Sample of Insulation. 20. The insulation shall be removed entirely from sufficient wire to give a sample weighing about 25 g. This shall be cut into small strips and ground slowly, so as not to heat the rubber, in either a No. 0 Enterprise coffee mill, a Russwinn grinder or a mill such as shown in Fig. 3. The grinder shall be adjusted so that not more than 20 per cent will pass through a 40-mesh sieve. All of the material shall be sifted through a 20-mesh sieve, what is retained on the sieve being reground until the entire sample has passed through. The wires of the sieves shall be evenly spaced in both directions and shall be of 0.016 and 0.010 in. in diameter in the 20 and 40-mesh sieves, respectively. Any metal that may have come from the grinder shall be removed with a strong magnet and the sample thoroughly mixed.

Extraction Apparatus. 21. The extraction apparatus shall conform to Fig. 1. It shall be heated so that the period of filling an empty siphon cup with acetone and completely emptying it will be between $2\frac{1}{2}$ and $3\frac{1}{2}$ minutes.

VII. REAGENTS.

22. Acetone shall be freshly distilled over anhydrous K_2CO_3, using the fraction 56–57° C. **Acetone.**

23. Alcoholic KOH solution shall be of normal strength and shall be made freshly by dissolving the proper amount of KOH (purified by alcohol) in 95-per-cent alcohol which has previously been distilled over KOH. The solution shall be allowed to stand for 24 hours and only the clear liquid used. **KOH.**

24. Ether shall be washed with three successive portions of distilled water and distilled, using the fraction 34–36° C. **Ether.**

25. Chloroform shall be pure and freshly distilled. **Chloroform.**

26. Carbon tetrachloride shall be pure and freshly distilled. **Carbon Tetrachloride.**

27. Reagents not otherwise specified shall be chemically pure. Water shall be distilled.

VIII. ANALYSES.

28. Extract continuously with 60 cc. of acetone for 8 hours, two 2-g. samples that have been prepared within 24 hours. Unite the extracts in a weighed flask, using hot chloroform to rinse the flasks. Distill off the reagents and dry the flask and contents for 4 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down the side of the flask. **Acetone Extract.**

29. Add to the acetone extract 50 cc. of alcoholic KOH solution, boil under a reflux condenser for 2 hours, and evaporate to dryness, removing all alcohol. Add 10 cc. of water and 20 cc. of ether; heat until the wax, etc., are in solution, cool, transfer to a separatory funnel, wash out the flask with warm water and then cool, finally with two 20-cc. portions of ether. The water volume should be 100 cc. and the ether at least 40 cc. Shake vigorously for 2 minutes, and allow the solutions to separate thoroughly. Draw off the aqueous solution into a second funnel, leaving in the first funnel the ethereal solution and any flocculent material that may be present. Again rinse the flask with 20 cc. of ether and add it to the aqueous solution; shake vigorously for 2 minutes, and when separated draw off the aqueous solution and unite in the first funnel the ethereal solutions and any flocculent material. Repeat, shaking with 20-cc. portions of ether until the extraction is complete, using at least 120 cc. of ether. Wash the flask and the funnel, from which the ethereal solution has been taken, with water, until they are free from alkali, subsequently using this wash water to wash the ethereal solution. **Unsaponifiable Matter.**

Continue washing with water until it has been washed twice after it shows no alkaline reaction. Retain with the ethereal solution any flocculent material. Filter the ethereal solution from the flocculent material, through a small pellet of extracted cotton, into a weighed flask, washing first with ether and subsequently with hot chloroform, using this to rinse the original flask and both separatory funnels. Evaporate the solvents and dry the extract to constant weight at 95 to 100° C.; desiccate until cool and weigh.

Hydrocarbons A. 30. Add 50 cc. of absolute alcohol to the unsaponifiable material and warm until solution is as complete as possible. Cool the solution to -4 or $-5°$ C. and maintain at this temperature for 1 hour by packing the flask in a mixture of ice and salt. Filter out the waxy hydrocarbons, using a funnel packed with ice and salt, and apply suction if necessary. Wash the flask and filter with about 25 cc. of 95-per-cent alcohol, which has been previously cooled in the same temperature. Catch the filtrate in a flask which is afterwards cooled to -4 or $-5°$ C. to make sure that all possible waxy hydrocarbons have been removed, and refilter if necessary. Dissolve the residue on the filter paper with hot chloroform, into the original flask. Evaporate the chloroform and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Hydrocarbons B. 31. Evaporate the alcohol from the flask containing the alcoholic soluble unsaponifiable material, add 25 cc. carbon tetrachloride and transfer to a separatory funnel. Shake with concentrated H_2SO_4, drain off the discolored acid and repeat with fresh portions of acid until there is no longer any discoloration. After drawing off all the acid, wash the carbon tetrachloride solution with repeated portions of water until all traces of acid are removed. Transfer the carbon tetrachloride solution to a weighed flask; evaporate off the solvent and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Free Sulfur. 32. Add 2 g. KNO_3 to the aqueous solution and washings from the ethereal separation of the unsaponified material. Evaporate to dryness in a silver or nickel dish and heat to quiet fusion, avoiding contamination with sulfur fumes. Transfer with water to an evaporating dish, acidify with HCl, evaporate to dryness, and dehydrate silica. Add 2 cc. of concentrated HCl, take up in water, filter and wash, making a volume of 200 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate the sulfur.

Chloroform Extract. 33. Extract continuously the residues from both of the acetone extractions (without necessarily removing the acetone that may be on them) for 4 hours with 60 cc. of chloroform, unite the extractions in a weighed flask, using hot chloroform to rinse the flasks. Distill off the solvent and dry the flask and contents for 2 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 1-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down the side of the flask. (If it is needful to wait after the acetone extraction, before starting the chloroform extraction, the sample must be kept in a vacuum of at least 50 mm. of mercury.)

Alcoholic KOH Extract.

34. Dry the residue from the chloroform extraction at 50 to 60° C. until odor of chloroform can no longer be detected, unite residues from the two 2-g. samples in a 200-cc. Erlenmeyer flask. Add 100 cc. of alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution by decantation through an 11-cc. hardened filter paper into a beaker and wash twice, using each time 25 cc. of hot absolute alcohol and then wash thoroughly with hot water. Wash any rubber on the filter paper back into the original flask and reserve this for the determination of the rubber hydrocarbons. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. of 5 *N* HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool, add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portions of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

Rubber Hydrocarbons.

35. Add to the flask containing the rubber residue from the alcoholic KOH extraction, sufficient water to make the total volume of the solution 125 cc. and then add 25 cc. of concentrated HCl. Heat for an hour at 97 to 100° C. Decant the supernatant liquid through a hardened filter paper on a Buchner funnel 7 cm. in diameter, using suction; wash the residue with 25 cc. of hot water and decant. (While a Buchner funnel is recommended, it is permissible to use an 11-cm. hardened filter paper with platinum cone, in a 60-deg. funnel.)

Perform this entire treatment with water and HCl three times and save the first and second decantations for the "organic matter" test described in Section 40. The rubber at this stage should be white and practically free from black specks of undissolved fillers; if not, continue the acid treatment until the black specks disappear. (If carbon is present, all the particles of rubber will be grayish, bluish, or black, depending on the form and quantity of carbon used. Black specks in light particles of rubber usually indicate the presence of lead sulfide which must be removed to prevent the formation of lead sulfate on igniting the residue *C*.) Add 150 cc. of hot water to the flask and let stand on a steam bath or hot plate for half an hour and decant through the filter paper, repeating until washings are free from chlorides. (See Section 40.) Transfer all the rubber in the flask to the filter paper and dry as much as possible by suction. Wash the rubber with 50 cc. of 95-per-cent alcohol, using suction. Transfer the entire residue to a weighing bottle. Dry at 95 to 100° C. for an hour, cool in a vacuum desiccator under reduced pressure and weigh. Dry for 30 minutes, cool and weigh, repeating this process until either constant weight is reached or the weight starts to increase. Let this weight be represented by *C*. Determine the ash (*E*) on a portion (*D*) of this residue (*C*) and sulfur (*H*) on the remaining portion (*G*). Also determine the sulfur (*F*) on the ash (*E*). Perform the ash determination as described under ash in Rubber Residue and the sulfur determinations as described under Total Sulfur. Then,

$$\text{Rubber hydrocarbons} = 100\,\frac{C}{4}\left(1-\frac{H}{C}-\frac{E-F}{D}\right)$$

expressed as a percentage of the total sample.

Ash in Rubber Residue. 36. Place about 0.5 g. (*D*) of residue *C* into a weighed porcelain crucible and heat gently, gradually driving off the volatile matter. When the crucible has ceased to smoke, raise the temperature gradually to between 450 and 500° C., until all organic matter has been burned away, which is usually indicated by the ash becoming white. (An electric muffle furnace with pyrometer is recommended for this purpose.) Cool in a desiccator and weigh, the weight of ash being represented by *E* in the formula for rubber hydrocarbons. Make the sulfur test on ash by the method described in Section 37. If, however, the ash (*E*) is not over 0.08 *D*, the determination of sulfur in the ash may be omitted, and *F* assumed to be zero.

Total Sulfur. 37. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion, and then bring to quiet fusion for 15 to 20 minutes. Apply the heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put the crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate silica; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 100 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

Specific Gravity.

38. The specific gravity shall be the ratio of the weight of a given volume of the rubber to the weight of an equal volume of water, both at 20° C. Strips of the largest applicable size shall be cut from the conductor and about 5 g. used for the sample. The specific gravity shall be determined in the usual manner by means of a specific gravity bottle. Care must be taken that no air bubbles adhere to the sample.

Red Lead.

39. Dissolve 1 g. of the sample in 75 cc. of xylol at a temperature of about 100° C. When the rubber is dissolved, the absence of any red particles indicates the absence of red lead. If red particles are present, filter the solution into a Gooch crucible and wash thoroughly with benzol, acetone and alcohol successively. Remove the felt and residue to a distilling flask, add HCl, and distill over the chlorine liberated by the lead peroxide, absorbing the gas in a solution of KI and starch. Not more than 0.1 cc. of 0.1 *N* thiosulfate shall be required to titrate the iodine liberated.

Organic Filler.

40. Transfer the first and second decantations of the HCl solutions to a carefully cleaned porcleain dish and add 20 cc. of concentrated H_2SO_4. Place the dish on a steam bath or hot plate to drive off water and HCl. A pronounced charring of the residue indicates the presence of organic matter soluble in water or hydrolyzed by HCl. Examine the filter paper and rubber while decanting the acid solution and washing free of chlorides. Some types of organic fillers not removed by water and HCl would be plainly visible at this point. Place a small portion of residue *C* under a microscope and examine for fibrous and other characteristic organic material. If organic fillers are indicated and not clearly proved by this test, place 1 g. of the original sample in a beaker, add 50 cc. of xylol and heat on a hot plate until the rubber is dissolved. Decant the xylol solution and wash

the residue with ether several times by decantation. Dry the residue and examine under the microscope.

IX. DEFINITIONS OF TERMS DESCRIBING COMPONENTS OF ACETONE EXTRACT.

Organic Extract.

41. *Organic Acetone Extract.*—In the case of chemical analysis of rubber, the difference between the acetone extract and the free sulfur.

Saponifiable Acetone Extract.

42. *Saponifiable Acetone Extract.*—In the case of chemical analysis of rubber, the difference between the organic acetone extract and the unsaponifiable material.

Waxy Hydrocarbon.

43. *Total Waxy Hydrocarbons.*—In the case of chemical analysis of rubber, the sum of the hydrocarbons A and B.

Unsaponifiable Resins.

44. *Unsaponifiable Resins.*—In the case of chemical analysis of rubber, the difference between the unsaponifiable material and the waxy hydrocarbons.

X. CHECK ANALYSES.

Checks.

45. Specific gravity determinations shall check within 0.01. The other duplicate determinations shall check within the following limits expressed as percentages of the original sample.

DETERMINATION.	CHECK.
Acetone extract	0.10
Saponifiable acetone extract	0.10
Unsaponifiable resins	0.10
Waxy hydrocarbons	0.10
Free sulfur	0.05
Chloroform extract	0.10
Alcoholic potash extract	0.10
Rubber hydrocarbons	0.20
Total sulfur	0.10

XI. INTERPRETATION.

Interpretation.

46. The rubber shall be considered to be the sum of the rubber hydrocarbons, saponifiable acetone extract, unsaponifiable resins and chloroform and alcoholic potash extracts, expressed as percentages. If the chloroform extract is over 3.0 per cent of the rubber so calculated, subtract the excess from the rubber. If the KOH extract is over 1.8 per cent of the rubber as first calculated, subtract this excess also from the rubber.

XII. STATEMENT OF RESULTS.

Statement of Results.

47. The results of the analysis shall be stated in the following form:

	PER CENT.
Acetone extract	....
Saponifiable acetone extract	....
Unsaponifiable resins	....
Waxy hydrocarbons	....
Free sulfur	....
Chloroform extract	....
Alcoholic potash extract	....
Total sulfur	....
Rubber	....
Color of acetone extract (60 cc. vol.)	....
Fluorescence in acetone extract solution (present or absent)	....
Hydrocarbons A (consistency and color	....
Hydrocarbons B (solid or liquid)	....
Color of chloroform extract (60 cc. vol.)	....
Carbon (present or absent)	....
Red lead (present or absent)	....
Specific gravity	......

II. PHYSICAL TESTS.

Scope.

48. (*a*) These tests are intended to apply to soft vulcanized rubber compounds such as are used for lining and cover of hose, belting, gloves used by electrical workers, etc.

(*b*) Only those tests which are applicable to rubber products in general have been covered. Tests which are special for only one class of material are not included since such tests more properly belong in the specifications for the particular material.

Selection and Condition of Samples.

49. (*a*) Samples shall be selected in accordance with the requirements of the specifications covering the material to be tested.

(*b*) The samples shall be taken from the finished product and shall not be heated, immersed in water or subjected to any mechanical or chemical treatment not specifically prescribed herein.

Age of Samples.

50. No tests shall be made within 48 hours after vulcanization unless agreed to by the manufacturer.

Temperature.

51. (*a*) The temperature of the surrounding air where samples of rubber are being tested shall not be less than 65° F. (18.3° C.) nor more than 90° F. (32.2° C.).

(*b*) The samples shall be kept at a temperature within these limits for at least 3 hours immediately before being tested.

Separation of Rubber.

52. When the tests to be made require the separation of the rubber from cotton fabric, it shall be done without the use of gasoline if possible. If it is necessary to use gasoline, it shall be of a grade which distills below 239° F. (115° C.) and the specimen shall be allowed to rest at least one hour before being tested.

(*A*) *Tensile Strength, Elongation and Set Tests.*

XIII. TENSION TESTING APPARATUS.

Type. 53. (*a*) Tensile strength and elongation tests shall be made on a power-driven apparatus, preferably of the inclination-balance or pendulum type. A spring balance type of apparatus may be used if provided with a device which will indicate the actual maximum load at which rupture took place, and provision is made to prevent recoil of the spring.

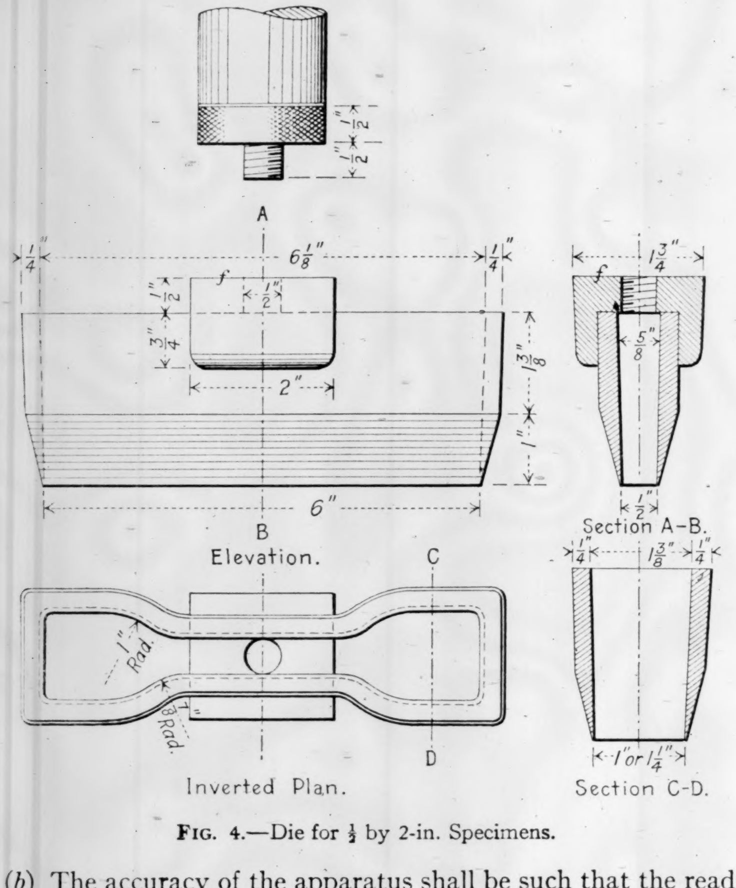

1/2"
1/2"
A
1/4"
6 1/8"
1/4"
f
1/2"
1/2"
3/4"
2"
1 3/8"
1"
6"
B
Elevation.
1 3/4"
f
5/8"
1/2"
Section A-B.
1/4"
1 3/8"
1/4"
C
1" Rad.
1/8 Rad.
D
Inverted Plan.
1" or 1 1/4"
Section C-D.

FIG. 4.—Die for ½ by 2-in. Specimens.

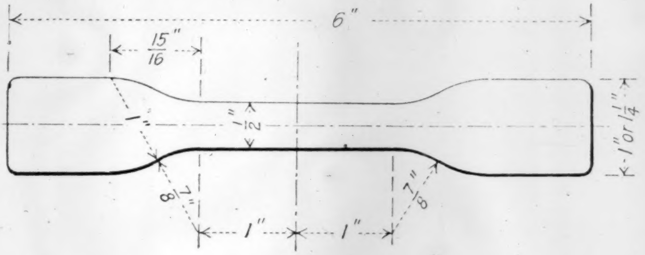
Accuracy. (*b*) The accuracy of the apparatus shall be such that the readings obtained are correct within ± 1 per cent.

Grips. (*c*) The grips which hold the specimen in the testing machine shall be of any desired type which tightens automatically and exerts a uniform pressure across the width of the specimen proportional to the applied tension.

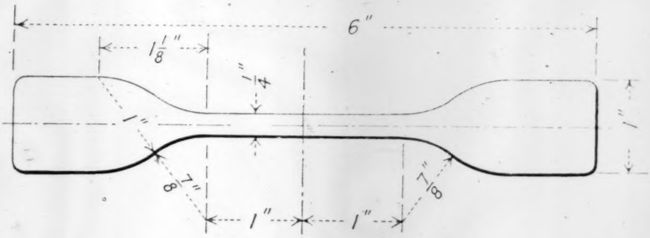
(*d*) The rate of separation of the grips shall be uniform at all times and approximately 20 in. per min. **Rate.**

XIV. TEST SPECIMENS.

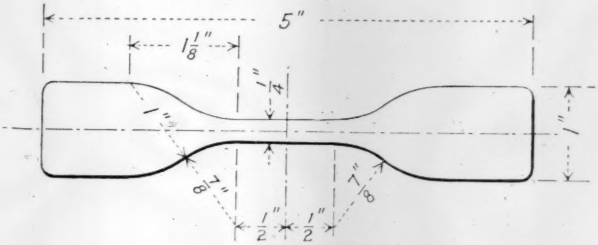
54. (*a*) Unless otherwise prescribed in the specifications for the material being tested, the specimens for tensile strength and elongation tests and those for set tests shall be stamped out with a steel die constructed substantially in accordance with Fig. 4, the specimen to have a reduced section at the center 2 in. long and 0.5 in. wide, 2 in. long and $\frac{1}{4}$ in. wide or 1 in. long and $\frac{1}{4}$ in. wide as shown in Fig. 5. The largest specimen that can be readily cut from the sample shall be used. **Shape.**



(*a*) $\frac{1}{2}$ by 2-in. Specimen.



(*b*) $\frac{1}{4}$ by 2-in. Specimen.



(*c*) $\frac{1}{4}$ by 1-in. Specimen.

FIG. 5.—Tensile Strength and Elongation Test Specimens.

Buffing. (*b*) All backing and deep corrugations as in seamless woven or braided hose shall be carefully removed by means of a suitable grinding machine and without causing excessive heating. It is recommended that a grinder similar to that shown in Fig. 6 be used.

At least one hour shall elapse between the buffing and testing of the specimen.

Gage Marks. (*c*) Two parallel lines perpendicular to the axis of the specimen shall be marked on the reduced section, one on each side of the center and 0.5 in. or 1 in. therefrom as required. The marks shall be as narrow as possible consistent with legibility.

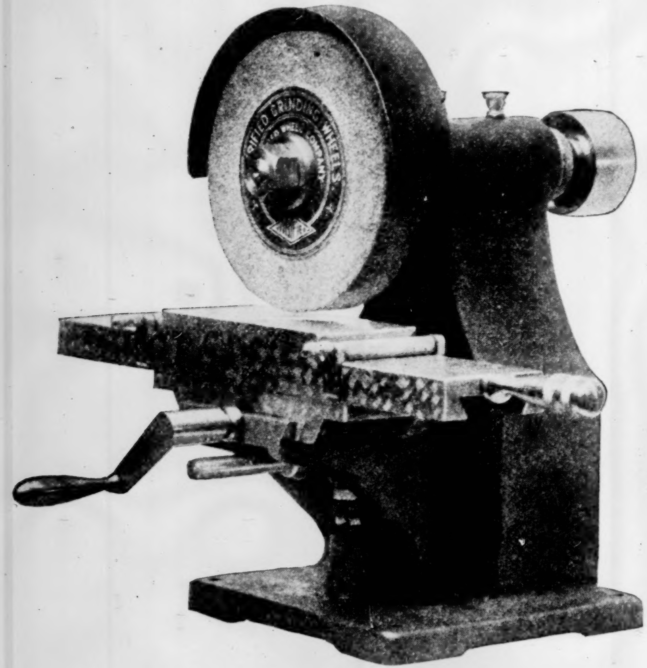


FIG. 6.—Grinder.

Dimensions. (*d*) The thickness shall be measured with a micrometer graduated to 0.001 in. having circular shoes 0.24 to 0.26 in. in diameter and with a pressure on the specimen of not less than 8 oz. nor more than 10 oz.

The minimum thickness and width between the gage marks shall be taken in calculating the area to be used in determining the tensile strength of the specimen.

Number of Test Specimens. 55. (*a*) One specimen per sample shall be tested for tensile strength and elongation. If either the tensile strength or the elongation is below the specified value, two additional specimens shall be tested. If either specimen falls below the specified value for either tensile strength or elongation, the material represented by the sample from which the specimens were taken shall be considered to have failed to meet the specifications.

(*b*) One specimen per sample shall be tested for set. If it fails to meet the specifications, the procedure shall be the same as in Section 55 (*a*).

(*c*) If a specimen breaks outside of the gage marks in the tensile strength and elongation tests, or is found to have been defective in either the tension test or the set test, it shall be discarded and the test repeated on a new specimen.

XV. PROCEDURE.

Tensile Strength and Elongation.

56. (*a*) With the specimen gripped evenly in the grips of the testing machine, the grips are separated at a uniform rate of approximately 20 in. per min. until rupture occurs. The distance between the gage marks shall be noted continuously so that at the instant of rupture the distance is known within 0.1 in.

The load at rupture in pounds divided by the minimum original area of the specimen at the reduced section in square inches shall be taken as the tensile strength in pounds per square inch. The distance between the gage marks at rupture in inches to the nearest 0.1 in., minus the original gage length, shall be taken as the elongation.

Set.

(*b*) The specimen shall be stretched until the distance between the gage marks is the prescribed amount, held stretched this amount for 10 minutes and then released. After the lapse of 10 minutes, the distance between the gage marks shall be measured to the nearest 0.02 in. The difference between the final distance and the original distance, divided by the original distance and expressed as percentage, shall be taken as the set.

(*B*) *Friction Tests.*

XVI. TEST SPECIMENS.

Fire Hose.

57. (*a*) The test specimens shall be pieces of the hose 2 in. in length accurately cut from the sample with a sharp tool which will leave clean edges. These rings shall then be slit in the lengthwise direction of the hose and laid out flat. One-quarter inch of the rubber lining shall be carefully and cleanly trimmed off on each side without injuring the fabric leaving a strip of rubber lining $1\frac{1}{2}$ in. in width undisturbed on a strip of cover 2 in. in width.

Other Types of Hose. (*b*) The test specimens shall be pieces of the hose 1 in. in length accurately cut from the sample with a sharp tool which will leave clean edges. They shall be tested in the ring form.

Belting. (*c*) A strip 6 in. in length by 1 in. in width shall be cut from the sample of belting with a sharp tool which will leave clean edges Two test specimens of two plies each shall be taken from this strip and tested separately.

Number of Test Specimens. 58. One specimen per sample shall be tested for friction. If the result is below the specified value, two additional specimens shall be tested. If either of these specimens falls below the specified value, the material represented by the sample from which the specimens were taken shall be considered to have failed to meet the specifications.

XVII. PROCEDURE.

Fire Hose and Belting. 59. (*a*) The plies, the friction between which is to be tested, shall be separated by hand at one end of the specimen a sufficient distance to permit attaching the grips.

With one separated end clamped in a stationary grip, the other separated end is clamped in a freely suspended grip hanging vertical and to which the prescribed weight is attached with suitable provision for supporting and releasing it slowly without jerking. The distance through which separation takes place shall be noted for a period of 10 minutes if possible. The friction shall be taken as the rate obtained by dividing the total distance separated in inches (to nearest 0.05 in.) by the elapsed time in minutes (to the nearest 0.017 min., that is, one second.)

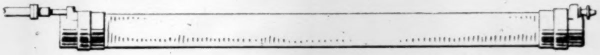
Other Types of Hose. (*b*) The test specimen shall be placed on a mandrel having a diameter equal to the nominal diameter of the hose. The cover shall be cut through in the lengthwise direction of the hose and enough of one end separated from the rubber to permit attaching a grip. With the mandrel held stationary, the prescribed weight shall be attached to the grip and the test carried out as prescribed for fire hose in Paragraph (*a*).

(*C*) *Hydrostatic Tests of Hose.*

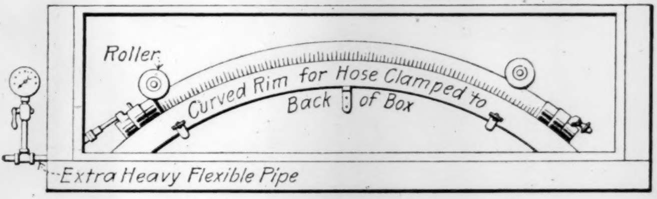
Application and Measurement of Pressure. 60. Pressure tests shall be made with water by means of a pump or by means of an accumulator system. The pressure shall be increased at a constant rate of 300 lb. per min. and shall be measured with a calibrated gage.

Fire Hose. 61. (*a*) *Tests of Each Length.*—The hose shall be stretched on a plane surface in a straight line and connected to the water line or pump and filled with water, the air being allowed to escape through an air cock. When the hose is filled with water the air cock shall be closed, a pressure of 10 lb. per sq. in. applied and the length carefully measured.

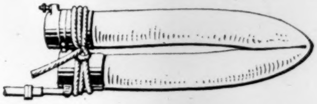
The pressure shall then be increased to the prescribed value and held for the prescribed period. While still under this pressure the length shall be measured and the amount of twist, warp and rise shall be determined.



Test 1. Hose Straight.


Roller
Curved Rim for Hose Clamped to Back of Box
Extra Heavy Flexible Pipe

Test 2. Hose Curved on Radius of $2\frac{1}{4}$ feet.



Test 3. Hose Kinked, Ends Tied Together.

FIG. 7.—Apparatus for Pressure Test.

(*b*) *Tests of Samples.*—The arrangement of the sample for various proof tests—straight, curved and kinked—shall be substantially as indicated in Fig. 7 except that in the kink test of a full length, the two parts of the hose made by the kink shall be tied together at a point 18 in. from the kink.

If the sample fails in this test, two additional samples shall be tested and if either of these fails, the entire lot of hose represented by the samples shall be considered to have failed to meet the specifications.

Other Types of Hose.

62. In testing samples of other types of hose, the pressure shall be raised at the above rate until the prescribed pressure is reached and then held for the prescribed period, after which the pressure shall be increased at the same rate until failure occurs.

If the sample fails in this test, two additional samples shall be tested and if either of these fails the entire lot of hose represented by the samples shall be considered to have failed to meet the specifications.

TENTATIVE SPECIFICATIONS

FOR

IMPERFECTIONS AND TOLERANCES FOR SQUARE-WOVEN TIRE FABRICS[1]

Serial Designation: D 122 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1921; Revised, 1922, 1923

IMPERFECTIONS

(*A*) *Classification*

1. Imperfections shall be those defects in material and workmanship which are in large measure capable of reduction and control by supervision and which, though important, do not form an essential element of the specifications. They may be classified as such deviations from the qualitative characteristics of the perfect fabric as shall materially depreciate its commercial value.

Classification. 2. The imperfections as defined may be classified into three groups for practical purposes: Major defects, minor defects, and special defects, as follows:

Major Defects
- Thick Places
- Thin Places
- Missing Warp Thread
- Pucker
- Bad Start-up

Minor Defects
- Thick Places
- Thin Places
- Slack Threads
- Tight Threads
- Slug
- Sewed Thread
- Knot
- Mispick or Broken Pick
- Float
- Reed Mark
- Split or Chafed Yarn
- Dirty Yarn
- Wrong Ply Warp Thread
- Wrong Draw

Special Defects
- Oil Spot
- Mixed Filling, Inferior Grade
- Smashes
- Imperfect Selvage
- Wrong Ply Filling Threads

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Russell T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

(*B*) *Nomenclature and Definitions*

Major Defects.

3. *Major Defects.*—

(*a*) *Thick and Thin Places.*—In the case of major defects, places in the fabric where for one inch or more the count varies ten per cent or over from the specified count.

(*b*) *Missing Warp Thread.*—A place in the fabric where a portion of the warp thread is missing.

(*c*) *Pucker* (*Puff or Blister*).—A series in the fabric of six or more tight or slack warp threads.

(*d*) *Bad Start-up.*—A defect in fabric due to faulty starting-up of the loom resulting in removal of filling thread, usually resulting in chafed or tight and loose warp threads, thin selvage or excessive bow, or any combination of them.

Minor Defects.

4. *Minor Defects.*—

(*a*) *Thick and Thin Places.*—In the case of minor defects, places in the fabric where for less than one inch the count varies ten per cent or over from the specified count.

(*b*) *Slack and Tight Warp or Filling Threads.*—Threads having too little or too much tension, respectively.

(*c*) *Slug.*—A bunch of lint entangled in the fabric.

(*d*) *Sewed Thread.*—A thread in the fabric interwoven by hand.

(*e*) *Knot.*—A joining of portions of a full-ply thread in the fabric by tying.

(*f*) *Mispick or Broken Pick.*—A streak across the width of the fabric caused by a missing or partly missing pick.

(*g*) *Float.*—A place in the fabric where warp and filling threads are incorrectly interlaced.

(*h*) *Reed Mark.*—An irregularity in the warp count of fabric caused by a sprung reed or other cause.

(*i*) *Split or Chafed Yarn.*—One or more ends of ply yarn broken in the fabric and chafed into a bunch.

(*j*) *Dirty Yarn.*—Requires no definition.

(*k*) *Wrong Ply Warp Thread.*—Requires no definition.

(*l*) *Wrong Draw.*—A streak lengthwise of fabric where the filling floats over more than one thread due to a warp thread having been drawn through the wrong harness.

Special Defects.

5. *Special Defects.*—

(*a*) *Oil Spot.*—Requires no definition.

(*b*) *Mixed Filling Yarn of Inferior Grade.*—Requires no definition.

(*c*) *Smash.*—A place in fabric where the warp threads have been broken due to the shuttle getting caught in the shed during weaving.

(*d*) *Imperfect Selvage.*—Tight, loose, cut, weak, or nicked selvage.

(*e*) *Wrong Ply Filling Thread.*—Requires no definition.

(*C*) *Scoring System of Grading*

Grading.

6. Scoring shall be based on major and minor defects, all major defects counting alike, and all minor defects counting alike.

7. On a basis of four major defects or twenty minor defects, or any combination of these, being permissible in a roll of 100 sq. yd., the scoring shall be as follows:

Deduct 25 from 100 for each major defect in 100 sq. yd.
Deduct 5 from 100 for each minor defect in 100 sq. yd.
Add the remainders, which shall be the score.

8. (*a*) Any roll of 100 sq. yd. giving a sum of 100 or above shall be graded *Grade A*.

(*b*) Any roll of 100 sq. yd. giving a sum below 100 shall be graded *Grade B*.

9. (*a*) *Grade A* shall be understood to be first class (entirely satisfactory delivery).

(*b*) *Grade B* shall be subject to adjustment or rejection.

Example.—A roll of 100 sq. yd. contains 2 major, and 6 minor defects:

$$\begin{array}{rcr} 100 & \qquad\qquad & 100 \\ -50 & & -30 \\ \cline{1-1}\cline{3-3} 50 & & 70 \end{array}$$

$$50+70=120 \text{ (Grade } A\text{)}$$

Example.—A roll of 100 sq. yd. contains 3 major and 15 minor defects:

$$\begin{array}{rcr} 100 & \qquad\qquad & 100 \\ -75 & & -75 \\ \cline{1-1}\cline{3-3} 25 & & 25 \end{array}$$

$$25+25=50 \text{ (Grade } B\text{)}$$

Special Defects.

10. Special defects shall be subject to allowance or adjustment between the manufacturer and consumer and are not to be included in the scoring.

TOLERANCES

Tolerances.

11. Tolerances shall be the limit within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable

limits of the quantitative characteristics of the fabric as defined in the specifications. The following tolerances are based upon the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

Width.

12. (*a*) No individual measurement made to determine the width of the fabric shall be more than 2 per cent over or 1 per cent under the specified average width.

(*b*) The average width determined by measurements shall be not more than 1 per cent over nor 0.5 per cent under the specified average width.

Weight per Square Yard

13. The weight of the fabric determined by test shall be not more than:

(*a*) Two per cent over or under the specified weight per square yard for fabrics over 12 oz. per sq. yd. in weight.

(*b*) Three per cent over or under the specified weight per square yard for fabrics 12 oz. per sq. yd. or lighter.

Count per Inch.

14. (*a*) The average count of warp ends per inch determined by test shall be not more than 1 per cent over or 2 per cent under the specified count.

(*b*) The average count per inch of filling picks determined by test shall not vary from the specified count more than

±1 pick for fabrics counting not over 25 picks per inch
±$1\frac{1}{2}$ picks " " " $25\frac{1}{2}$ to 32 picks per inch
±2 " " " " over 32 picks per inch

Bow.

15. The bow determined by test shall be not more than 0.75 per cent of the width of the fabric in inches over or under the specified bow.

NOTE.—Bow should be ascertained by five determinations made throughout the roll commencing at least 10 yd. from either end of the roll.

Off Square.

16. The allowable variation in the off square of the fabric shall be 3 per cent over or under the specified percentage for off square.

Thickness (Gage).

17. The average thickness determined by test shall not vary more than 5 per cent under or over the specified thickness in fabrics made of combed staple, and not more than $7\frac{1}{2}$ per cent under or over the specified thickness in fabrics made of carded staple.

Tensile Strength.

18. The average tensile strength of the warp and the average tensile strength of the filling found by test shall be not less than the specified tensile strength.

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[1] 1921 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS

FOR

IMPERFECTIONS AND TOLERANCES FOR CORD TIRE FABRICS[1]

Serial Designation: D 179 - 23 T

This is a Tentative Standard only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

IMPERFECTIONS

(*A*) *Classification*

1. Imperfections shall be those defects in material and workmanship which are in large measure capable of reduction and control by supervision and which, though important, do not form an essential element of the specifications. They may be classified as such deviations from the qualitative characteristics of the perfect fabric as shall materially depreciate its commercial value.

Classification. 2. The imperfections as defined may be classified into three groups for practical purposes: Major defects, minor defects, and special defects, as follows:

Major Defects

- Thick Places
- Thin Places
- Missing Cord
- Knots of finished cord

Minor Defects

- Thick Places
- Thin Places
- Slack Cord
- Tight Cord
- Slug
- Mispick or Broken Pick
- Float
- Chafed Cord
- Dirty Yarn
- Wrong Ply Cord
- Wrong Draw
- Corkscrew Twist
- Kinks

Special Defects

- Oil Spot
- Smashes
- Imperfect Selvage
- Baggy Fabrics
- Irregular Picks
- Mixed Cords
- Defective Splice

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Russell T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

(*B*) *Nomenclature and Definitions*

Major Defects.

3. *Major Defects.*—

(*a*) *Thick and Thin Places.*—In the case of major defects, places in the fabric where for one inch or more the filling count varies fifty per cent or over from the specified count.

(*b*) *Missing Cord.*—A place in the fabric where a portion of the warp cord is missing.

(c) *Knots of Finished Cord.*—A place in the fabric where a full-ply cord is joined by a knot.

Minor Defects.

4. *Minor Defects.*—

(*a*) *Thick and Thin Places.*—In the case of minor defects, places in the fabric where for less than one inch the filling count varies fifty per cent or over from the specified count.

(*b*) *Slack and Tight Cords.*—Cords having too little or too much tension, respectively.

(*c*) *Slug.*—A bunch of lint entangled in the cord.

(*d*) *Corkscrew Twist.*—A place in the cord where an uneven twist gives a corkscrew appearance.

(*e*) *Mispick or Broken Pick.*—A streak across the width of the fabric caused by a missing or partly missing pick.

(*f*) *Float.*—A place on the fabric where warp and filling threads are incorrectly interlaced.

(*g*) *Kink.*—A place in the fabric where a slack strand twists on itself forming a loop on the cord.

(*h*) *Chafed Cord.*—One or more ends of ply yarn broken in the cord and chafed into a bunch.

(*i*) *Dirty Cord.*—Requires no definition.

(*j*) *Wrong Ply Cord.*—Requires no definition.

(*k*) *Wrong Draw.*—A streak lengthwise of the fabric where the filling floats over more than one thread due to a warp cord having been drawn through the wrong harness.

Special Defects.

5. *Special Defects.*—

(*a*) *Oil Spot.*—Requires no definition.

(*b*) *Irregular Picks.*—Places in the fabric where the picks are irregularly spaced.

(*c*) *Smash.*—A place in fabric where the warp cords have been broken due to the shuttle getting caught in the shed during weaving.

(*d*) *Imperfect Selvage.*—Tight, loose or broken selvage.

(*e*) *Baggy Fabric.*—Loose places in the fabric which give the appearance of bags or pockets.

(*f*) *Mixed Cord.*—Requires no definition.

(*g*) *Defective Splice.*—A splice having irregular final twist, untrimmed ends or excessive gage.

(*C*) *Scoring System of Grading*

Grading. 6. Scoring shall be based on major and minor defects, all major defects counting alike, and all minor defects counting alike.

7. On a basis of four major defects or twenty minor defects, or any combination of these, being permissible in a roll of 100 sq. yd., the scoring shall be as follows:

Deduct 25 from 100 for each major defect in 100 sq. yd.
Deduct 5 from 100 for each minor defect in 100 sq. yd.
Add the remainders, which sum shall be the score.

8. (*a*) Any roll of 100 sq. yd. giving a sum of 100 or above shall be graded *Grade A*.

(*b*) Any roll of 100 sq. yd. giving a sum below 100 shall be graded *Grade B*.

9. (*a*) *Grade A* shall be understood to be first class (entirely satisfactory delivery).

(*b*) *Grade B* shall be subject to adjustment or rejection.

Example.—A roll of 100 sq. yd. contains 2 major and 6 minor defects.

$$\begin{array}{r} 100 \\ -50 \\ \hline 50 \end{array} \qquad\qquad \begin{array}{r} 100 \\ -30 \\ \hline 70 \end{array}$$

$$50+70=120 \text{ (Grade } A\text{)}$$

Example.—A roll of 100 sq. yd. contains 3 major and 15 minor defects.

$$\begin{array}{r} 100 \\ -75 \\ \hline 25 \end{array} \qquad\qquad \begin{array}{r} 100 \\ -75 \\ \hline 25 \end{array}$$

$$25+25=50 \text{ (Grade } B\text{)}$$

10. Special defects shall be subject to allowance or adjustment between the manufacturer and consumer and are not to be included in the scoring.

TOLERANCES

Tolerances. 11. Tolerances shall be the limit within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable limits of the quantitative characteristics of the fabric as defined in the specifications. The following tolerances are based upon the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

Width.

12. (*a*) No individual measurement made to determine the width of the fabric shall be more than 2 per cent over or 1 per cent under the specified average width.

(*b*) The average width determined by measurements shall be not more than 1 per cent over nor 0.5 per cent under the specified average width.

Weight per Square Yard

13. The weight of the fabric determined by test shall be not more than:

(*a*) Two per cent over or under the specified weight per square yard for fabrics over 12 oz. per sq. yd. in weight.

(*b*) Three per cent over or under the specified weight per square yard for fabrics 12 oz. per sq. yd. or lighter.

Count per Inch.

14. (*a*) The average count of warp ends per inch determined by test shall be not more than 1 per cent over nor 2 per cent under the specified count.

(*b*) The average count per inch of filling picks determined by test shall not vary from the specified count more than 10 per cent.

Thickness (Gage).

15. The average thickness of the cord determined by test shall not vary more than 3 per cent under or over the specified thickness in cords made of combed staple, and not more than 5 per cent under or over the specified thickness in cords made of carded staple.

Tensile Strength.

16. The average tensile strength of the cord found by test shall be not less than the specified tensile strength.

Twist.

17. The average ply twist found by test shall not vary more than 5 per cent above or below the specified twist.

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[1] 1921 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES AND TEST METHODS FOR COTTON YARNS AND CORDS[1]

Serial Designation: D 180 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

Issued, 1923

Scope. 1. These specifications cover the tolerances and methods of testing for cotton yarn, both single and plied, and apply to either carded or combed yarn.

TOLERANCES

I. STRENGTH

Strength of Single Yarn. 2. The average tensile strength of each case or beam of single yarn as found by test shall be not less than the specified strength.

Strength of Plied Yarn. 3. The average tensile strength of each case of plied yarn as found by test shall be not less than the specified strength.

II. SIZE OR YARN NUMBER

Size of Single Yarn. 4. (*a*) The average size of each case or beam of single yarn as found by test shall not vary more than 7 per cent above or below that specified.

Example.—Case or beam size specified as No. 20; tolerance 18.6 to 21.4.

(*b*) The average size of each shipment (10 or more cases or beams) of single yarn as found by test, shall not vary more than 5 per cent above or below that specified.

Example.—Shipment size specified as No. 20; tolerance 19 to 21.

Size of Plied Yarns. 5. (*a*) The average size of each case of plied yarn as found by test shall not vary more than 7 per cent above or below that specified.

Example.—Case size specified as No. 1.50; tolerance 1.395 to 1,605.

(*b*) The average size of each shipment (10 cases or more) of plied yarn as found by test shall not vary more than 5 per cent above or below that specified.

Example.—The shipment size specified as No. 1.50; tolerance 1.425 to 1.575.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Russell T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

III. TWIST AND DIRECTION OF TWIST

Definition.

6. *Direction of Twist.*—A yarn or cord is said to contain right-hand twist when the spirals or twists run upward in a right-hand direction, when the yarn or cord is held in a vertical position, and *vice versa* for left-hand twist.

Twist of Plied Yarns.

7. The average twist of each case of plied yarn as found by test shall not vary more than 5 per cent above or below that specified.

Example.—Twist specified as 12 twists per in.; tolerance 11.4 to 12.6.

METHODS OF TESTING

IV. STRENGTH

Single Yarn.

8. (*a*) *Skein Test.*—A standard skein (120 yd.) shall be broken after conditioning so as to contain a moisture regain of 7 per cent obtained either (1) after conditioning of the tubes or bobbins for 12 hours[1] or (2) after conditioning of skeins for at least 2 hours. An automatic yarn power tester of inclination balance type, the maximum capacity of which shall be determined in accordance with a table of machine specifications, shall be used. The speed of the pulling jaw shall be 12 in. per minute. Any yarn reel having a $1\frac{1}{2}$-yd. perimeter may be used in preparing the skeins. For filling wound yarns or yarns on cones, where the yarn is drawn from the top, a speed of 100 to 300 r.p.m. of reel shall be used. For warp wound yarns or yarn on parallel tubes where yarn is drawn from the side, a speed of 20 to 30 r.p.m. of reel shall be used. On reels that have only one pigtail guide, tension shall be applied by making one full wrap of the yarn around the guide. On reels using two or more guides, the yarn shall pass straight through the guides onto the reel, the angles of the guides supplying the necessary tension. Judgment must be used in regard to the amount of tension required on yarns having very soft, or an excessive amount of twist. Three tests from each of four bobbins from every case of yarn shall be made.

(*b*) *Single Strand Test.*—Single strands shall be broken after conditioning the tubes or bobbins for 12 hours so as to contain a moisture regain of 7 per cent. A single strand tester of proper capacity, with the jaws set 10 in. between grips and having a speed of pulling jaw of 12 in. per minute shall be used. The average of ten breaks from each of four bobbins shall be the average strength. This test shall be used for yarns received on beans, etc. To prepare specimens for test, at least 60 ends, 48 in. long, shall be unwound from the beam.

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[1] It is assumed that the entire tube will not condition properly; therefore, yarn for tests shall be taken from the outside of the tube after conditioning and shall not penetrate into the tube more than $\frac{1}{4}$ in. on a radial line.

The bundle shall be held at one end to allow ends to twist upon themselves. A knot shall be tied in each end and the bundles allowed to condition as specified in Paragraph (*a*). After conditioning, one end of the bundle shall be clamped in the head end jaw of any twist counter, and the other end shall be held by any suitable means, applying approximately the same tension as is used in preparing skeins on reels. The bundle shall be untwisted until strands are parallel, 60 ends counted off and cut from bundle to a measure of one yard in length. Knots shall again be tied in each end and the size of the 60 yd. determined in accordance with Section 10. After the size has been determined the strands shall again be made parallel, removed one by one, and broken on a single strand tester. The average of 20 breaks shall be reported as the average strength.

(*c*) *Strength Correction to Size.*—The average tensile strength shall be corrected to the specified size as determined in accordance with Section 10 by the following formula:

$$\text{Corrected Strength} = \text{Actual Average Strength} \times \frac{\text{Actual Average Size}}{\text{Specified Size}}$$

Strength of Plied Yarns.

9. Plied yarns, except standard tire cord, shall be subjected to the single strand break test after conditioning for 12 hours on spools or tubes to contain a moisture regain of 7 per cent. Standard tire cord shall be tested under dry conditions in accordance with the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1] A single strand tester of proper capacity with the jaws set 10 in. between grips and having a speed of pulling jaw of 12 in. per minute shall be used. The average of 10 breaks from each of four spools or tubes shall be reported as the average strength.

V. SIZE OR YARN NUMBER

Size of Single Yarns.

10. The size of all standard skeins used in the skein strength test described in Section 8 (*a*) shall be determined immediately after being broken. In case the single strand strength test is made, the standard skein shall be prepared for the size determination at the time of the break and the size determined immediately. The size of 60-yd. bundles prepared from beams as described in Section 8 (*b*) shall be determined as soon as possible after conditioning and one test from each beam shall be reported as the average size. The balance to be used in this test shall be accurate to 0.25 per cent of the standard size of the yarn.

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[1] 1921 Book of A.S.T.M. Standards.

Size of Plied Yarns.

11. In determining the size of plied yarns the skein shall be prepared in accordance with Table I, and the size shall be determined after conditioning to contain a moisture regain of 7 per cent, obtained either after (1) conditioning of the tubes or spools for 12 hours or (2) after conditioning the skeins for at least 2 hours. Any yarn reel having a $1\frac{1}{2}$-yd. perimeter may be used in preparing the skeins. For filling wound yarns or yarn on cones a speed of 100 to 300 r.p.m. of reel shall be used. For warp wound yarns or yarn on parallel tubes a speed of 20 to 30 r.p.m. of reel shall be used. On reels that have only one pigtail guide, tension shall be applied by making one full wrap of the yarn around the guide. On reels using two or more guides, the yarn shall pass straight through the guides onto the reel, the angles of the guides supplying the necessary tension.

TABLE I.

EQUIVALENT SINGLES SIZE	YDS. FOR SIZE	CONVERSION FORMULA	NUMBER OF TESTS PER CASE YARN
20's and above	60	$\frac{\text{Size}}{2}$ = Ply Size	3 from each of 4 spools or tubes
3's to 20's	24	$\frac{\text{Size}}{5}$ = Ply Size	3 from each of 4 spools or tubes
Below 3's	12	$\frac{\text{Size}}{10}$ = Ply Size	3 from each of 4 spools or tubes

VI. TWIST

Twist of Single Yarns.

12. No precision method for determining the twist of single yarns has been developed.

Twist of Plied Yarns.

13. The twist shall be determined on any standard twist counter with the jaws set 10 in. apart. The strands shall be clamped in jaws under a definite tension obtained by attaching weights. The tension to be used shall be determined from the following formula:

$$\text{Tension, Weight in Grams} = \frac{156}{\text{Equivalent Singles Size}}$$

Example.—The weight for 23/11 to be as follows:

$$\frac{156}{2.09} = 75 \text{ g.}$$

Three twist tests on each of four spools or tubes of yarn from each case shall be made, and the average of these twelve tests shall be reported as the average twist.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES FOR HOSE DUCKS AND BELT DUCKS[1]

Serial Designation: D 181 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Tolerances.

1. Tolerances shall be the limit within which a textile must come in its specified characteristics in order that it shall constitute a good delivery on contract. They may be classified as the allowable limits of the quantitative characteristics of the fabric as defined in the specifications. The following tolerances are based upon the Standard General Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[2]

I. WIDTH

Hose Ducks.

2. *Hose Ducks,* ranging in width from 40 to 72 in. inclusive:

(*a*) No individual measurement made to determine the width of the fabric shall be more than 2 per cent over or under the specified average width.

(*b*) The average width determined by measurements shall be not more than 1½ per cent over or under the specified average width.

Rubber and Balata Ducks.

3. *Rubber and Balata Belt Ducks,* ranging in width from 42 to 72 in., inclusive:

(*a*) No individual measurement made to determine the width of the fabric shall be more than 1½ per cent over or under the specified average width.

(*b*) The average width determined by measurements shall be not more than 1 per cent over or under the specified average width.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Russell T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

[2] 1921 Book of A.S.T.M. Standards.

Stitched Canvas Belting Ducks.

4. *Stitched Canvas Belting Ducks*, ranging in width from 16 to 72 in., inclusive:

(*a*) No individual measurement made to determine the width of the fabric shall be more than $\frac{1}{8}$ in. over or under the tolerance for the average width.

(*b*) The average width determined by measurement shall be as specified with the following tolerances:

	Tolerance, in.	
Width, in.	Over	Under
16 to 36, inclusive	$\frac{1}{4}$	$\frac{1}{4}$
37 to 60, inclusive	$\frac{3}{8}$	$\frac{1}{4}$
61 to 72, inclusive	$\frac{5}{8}$	$\frac{3}{8}$

II. WEIGHT

Normal Weight.

5. The weight of the fabric determined by test shall be not more than $2\frac{1}{2}$ per cent over or under the specified weight.

III. THREADS PER INCH

Hose Ducks.

6. *Hose Ducks.*—

(*a*) The average count of warp ends per inch determined by test shall be not more than 2 per cent over or under the specified count.

(*b*) The average count of filling picks per inch determined by test shall be not more than 4 per cent over or under the specified count.

Rubber Belt Ducks.

7. *Rubber Belt Ducks.*—

(*a*) The average count of warp ends per inch determined by test shall be not more than 2 per cent over or under the specified count.

(*b*) The average count of filling picks per inch determined by test shall be not more than 4 per cent over or under the specified count.

Stitched Canvas Belting Ducks.

8. *Stitched Canvas Belting Ducks.*—

(*a*) The average count of warp ends per inch determined by test shall be not more than 1 end over or under the specified count for fabrics counting not over 30 ends per inch and not more than $1\frac{1}{2}$ ends over or under for fabrics counting over 30 ends per inch.

(*b*) The average count of filling picks per inch determined by test shall be not more than 1 pick over or under the specified count for fabrics counting not over 15 picks per inch, and not more than $1\frac{1}{2}$ picks over or under for fabrics counting over 15 picks per inch.

IV. GAGE

Hose Ducks.

9. *Hose Ducks.*—The average thickness of the fabric shall be not more than 7 per cent over or under the specified average thickness.

Rubber and Balata Ducks.

10. *Rubber and Balata Belt Ducks.*—The average thickness of the fabric shall be not more than 5 per cent over or under the specified average thickness.

V. CRIMP

Crimp.

11. The average warp crimp and the average filling crimp shall be not more than 10 per cent over or under the specified crimp percentage.

VI. STRENGTH

Strength.

12. The average tensile strength of the warp and the average tensile strength of the filling shall be not less than the average specified tensile strength.

TENTATIVE SPECIFICATIONS
FOR
A.S.T.M. PARTIAL-IMMERSION THERMOMETER FOR GENERAL USE,
−20 TO +150° C., 0 TO +300° F.[1]

Serial Designation: D 182 − 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

1. These specifications cover a partial immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the ranges being −20 to +150° C. or 0 to +300° F., respectively.

2. The purpose of these specifications is to provide a thermometer of sufficient accuracy for general use in determining temperatures as required in tests where no standard thermometer is specified and for adoption as a standard where its design is applicable.

3. The thermometer shall conform to the following requirements:

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: −20 to +150° C. in 1° C. or 0 to +300° F. in 2° F.

TOTAL LENGTH: 303 to 307 mm. (11.94 to 12.11 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6 to 7 mm. (0.236 to 0.275 in.).

BULB: Corning normal or equally suitable thermometric glass.
Length, 19 to 25 mm. (0.75 to 1 in.).
Diameter, 5 to 6 mm. (0.196 to 0.236 in.).

DISTANCE TO −18° C. OR 0° F. LINE FROM BOTTOM OF BULB: 90 to 100 mm. (3.55 to 3.94 in.).

DISTANCE TO 150° C. OR 300° F. LINE FROM TOP OF STEM: 20 to 35 mm. (0.8 to 1.4 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION: The words "76-mm. immersion" on Centigrade thermometers, or "3-in. immersion" on Fahrenheit thermometers and a line around the stem, 75 to 77 mm. (2.96 to 3.04 in.) above the bottom of the bulb, shall be etched on the thermometer.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. E. F. Mueller, Secretary of Committee D-15 on Thermometers, U. S. Bureau of Standards, Washington, D. C.

SPECIAL MARKING: "A.S.T.M.," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale, when the thermometer is standardized as provided below, shall not exceed 0.5° for the Centigrade thermometer or 1° for the Fahrenheit thermometer.

STANDARDIZATION: The thermometer shall be standardized for 76-mm. (3-in.) immersion and for the following temperatures of the emergent mercury column. These stem temperatures have been chosen as corresponding, on the average, to those likely to occur in the use of the thermometer.

THERMOMETER READING	AVERAGE TEMPERATURE OF EMERGENT MERCURY COLUMN
50° C. (122° F.)	35° C. (94° F.)
100° C. (212° F.)	48° C. (118° F.)
150° C. (302° F.)	55° C. (131° F.)

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. −20 to +150° C., 76-mm. immersion" or "A.S.T.M. 0 to +300° F., 3-in. immersion," according to the type of thermometer.

TENTATIVE SPECIFICATIONS

FOR

A.S.T.M. PARTIAL-IMMERSION THERMOMETER FOR GENERAL USE,

−5 TO +300° C., +20 TO +580° F.[1]

Serial Designation: D 183 – 23 T

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ISSUED, 1923

1. These specifications cover a partial immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the ranges being −5 to +300° C. or +20 to +580° F., respectively.

2. The purpose of these specifications is to provide a thermometer of sufficient accuracy for general use in determining temperatures as required in tests where no standard thermometer is specified and for adoption as a standard where its design is applicable.

3. The thermometer shall conform to the following requirements:

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: −5 to +300° C. in 1° C. or +20 to +580° F. in 2° F.

TOTAL LENGTH: 379 to 383 mm. (14.92 to 15.08 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6 to 7 mm. (0.236 to 0.275 in.).

BULB: Corning normal or equally suitable thermometric glass.
Length, 10 to 15 mm. (0.39 to 0.59 in.).
Diameter, 5 to 6 mm. (0.196 to 0.236 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 90 to 100 mm. (3.94 to 4.33 in.).

DISTANCE TO 300° C. OR 572° F. LINE FROM TOP OF STEM: 25 to 50 mm. (1 to 2 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. E. F. Mueller, Secretary of Committee D-15 on Thermometers, U. S. Bureau of Standards, Washington, D. C.

IMMERSION: The words "76-mm. immersion" on Centigrade thermometers, or "3-in. immersion" on Fahrenheit thermometers and a line around the stem, 75 to 77 mm. (2.96 to 3.04 in.) above the bottom of the bulb, shall be etched on the thermometer.

SPECIAL MARKING: "A.S.T.M.," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale, when the thermometer is standardized as provided below, shall not exceed 1° for the Centigrade thermometer, or 2° for the Fahrenheit thermometer.

STANDARDIZATION: The thermometer shall be standardized for 76-mm. (3-in.) immersion and for the following temperatures of the emergent mercury column. These stem temperatures have been chosen as corresponding, on the average, to those likely to occur in the use of the thermometer.

THERMOMETER READING	AVERAGE TEMPERATURE OF EMERGENT MERCURY COLUMN
50° C. (122° F.)	35° C. (94° F.)
100° C. (212° F.)	49° C. (120° F.)
150° C. (302° F.)	61° C. (142° F.)
200° C. (392° F.)	70° C. (158° F.)
250° C. (482° F.)	76° C. (169° F.)
300° C. (572° F.)	80° C. (176° F.)

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. −5 to +300° C., 76-mm. immersion" or "A.S.T.M. 20 to 580° F., 3-in. immersion," according to the type of thermometer.

TENTATIVE SPECIFICATIONS
FOR
A.S.T.M. PARTIAL-IMMERSION THERMOMETER FOR GENERAL USE,
−5 TO +400° C., +20 TO +760° F.[1]

Serial Designation: D 184 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

1. These specifications cover a partial immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the ranges being −5 to +400° C. or +20 to +760° F., respectively.

2. The purpose of these specifications is to provide a thermometer of sufficient accuracy for general use in determining temperatures as required in tests where no standard thermometer is specified and for adoption as a standard where its design is applicable.

3. The thermometer shall conform to the following requirements:

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: −5 to +400° C. in 1° C. or +20 to +760° F. in 2° F.

TOTAL LENGTH: 404 to 408 mm. (15.92 to 16.06 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6 to 7 mm. (0.236 to 0.275 in.).

BULB: Corning normal or equally suitable thermometric glass.
Length, 10 to 15 mm. (0.39 to 0.59 in.).
Diameter, 5 to 6 mm. (0.196 to 0.236 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 100 to 110 mm. (3.94 to 4.33 in.).

DISTANCE TO 400° C. OR 752° F. LINE FROM TOP OF STEM: 25 to 50 mm. (1 to 2 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION: The words "76-mm. immersion" on Centigrade thermometers, or "3-in. immersion" on Fahrenheit thermometers and a line around the stem, 75 to 77 mm. (2.96 to 3.04 in.) above the bottom of the bulb, shall be etched on the thermometer.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. E. F. Mueller, Secretary of Committee D-15 on Thermometers, U. S. Bureau of Standards, Washington D. C.

SPECIAL MARKING: "A.S.T.M.," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale, when the thermometer is standardized as provided below, shall not exceed 1° up to 301° C. and 1.5° at higher points in the case of thermometers graduated in Centigrade degrees, or 2° up to 574° F. and 3° at higher points in the case of thermometers graduated in Fahrenheit degrees.

STANDARDIZATION: The thermometer shall be standardized for 76-mm. (3-in.) immersion and for the following temperatures of the emergent mercury column. These stem temperatures have been chosen as corresponding, on the average, to those likely to occur in the use of the thermometer.

THERMOMETER READING	AVERAGE TEMPERATURE OF EMERGENT MERCURY COLUMN
100° C. (212° F.)	50° C. (122° F.)
200° C. (392° F.)	75° C. (167° F.)
300° C. (482° F.)	89° C. (192° F)
400° C. (572° F.)	94° C. (201° F.)

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature 10° C. or 20° F. below the maximum scale temperature for 24 hours, the accuracy shall be within the limit specified.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. −5 to +400° C., 76-mm. immersion" or "A.S.T.M. 20 to 760° F., 3-in. immersion" according to the type of thermometer.

TENTATIVE METHODS
OF
VERIFICATION OF TESTING MACHINES[1]

Serial Designation: E 4 – 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

I. DEFINITIONS

1. (*a*) *Testing Machine.*—A mechanical device for applying a load (force) to a specimen.

NOTE.—Usually the magnitude of the load can be changed at the will of the operator. Many testing machines are arranged to measure the load, but this is not always the case, especially with impact machines and machines for testing ductility.

(*b*) *Error.*—In the case of a testing machine, the value obtained by subtracting the correct value of the quantity measured (usually load) from the indicated value as given by the testing machine.

NOTE.—The error may be positive or negative.

(*c*) *Percentage of Error.*—In the case of a testing machine, the ratio, expressed in per cent, of the error to the correct value of the quantity measured.

(*d*) *Correction.*—In the case of a testing machine, the value obtained by subtracting the indicated value from the correct value of the quantity measured.

NOTE.—The correction has the same magnitude as the error but the opposite sign.

It is recommended that, except for special cases, no corrections be used on machines tested and found to have errors within the tolerances given in these methods.

(*e*) *Tolerance.*—In the case of a testing machine, the maximum allowable error in the value of the quantity indicated.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. H. F. Moore, Chairman of Sub-Committee, of Committee E-1, on Mechanical Testing of Materials, University of Illinois, Urbana, Ill.

These methods, when adopted as Standard, will supersede the present directions for conditions to ensure correct testing machines and calibration of testing machines appearing as Sections 16 to 21, inclusive, of the Methods for Tension Tests of the Standard Methods of Mechanical Testing of Metallic Materials (Serial Designation: E 1 – 18), 1921 Book of A.S.T.M. Standards.

NOTE.—It is convenient to express tolerance in terms of percentage of error. The numerical value of the tolerance for a testing machine is so stated hereafter in these methods.

The word "accurate" applied to a testing machine shall be used without numerical values. The word "error" shall be used with numerical values. For example: "An accurate testing machine was used for the investigation"; but "The error of the testing machine at a load of 30,000 lb. was 15 lb." A testing machine is said to be accurate if the indicated load is within the specified tolerance of the actual load.

The *accuracy* of a testing machine should not be confused with *sensitiveness*. For example, a testing machine might be very sensitive—that is, it might indicate quickly and definitely small changes in the load—but, nevertheless, be very inaccurate. On the other hand, the accuracy of the results is, in general, limited by the sensibility.

(*f*) *Loading Range*.—In the case of a testing machine, the range of indicated loads for which the testing machine gives results within the specified tolerances. The loading range shall not include loads either greater than the largest load or less than the smallest load applied in verifying the testing machine.

II. METHODS FOR VERIFYING TESTING MACHINES THAT MEASURE LOAD

Direct Methods Recommended.

2. Wherever practicable, testing machines shall be verified by direct methods, that is, by applying standard weights directly to the weighing mechanism of the testing machine, or by the use of standardized proving levers in connection with standard weights. The test loads selected shall be applied in both ascending and descending order, and the indications for both the ascending series and the descending series of loads shall be considered in the application of tolerances.

NOTE.—For machines in which the load-indicating device is actuated by a Bourdon pressure tube, a hydraulic (or steam-engine) indicator spring, or other device depending on the elastic properties of a material, the tolerances for the *descending* load shall be applied to differences in the indication for the corresponding ascending and descending readings. In such testing machines the test for ascending load shall be applied as rapidly as practicable after the testing machine has remained unloaded for at least six hours, and the time of applying the ascending series of loads shall not exceed thirty minutes. The descending load test shall be made after the maximum test load has remained on the machine for one hour, and the readings for descending loads shall be taken as rapidly as possible, and in any event the descending load test shall be completed within a period of twenty minutes.

Selection of Test Loads.

3. For any loading range, the testing machine shall be verified by at least four test loads. It is recommended that the test loads

used be 10, 20, 50, and 100 per cent of the maximum capacity at which the testing machine is to be used.

NOTE.—Where a large amount of testing of small specimens is to be done on a large capacity machine, it is recommended that the verification outlined above be supplemented by a series of smaller test loads selected in reference to the light work to be done on the testing machine.

(A) *Method of Verification by Standard Weights*

Method by Standard Weights.

4. Standard metal weights of suitable design, finish, and adjustment shall be placed on the weighing platform of the testing machine or upon trays or other supports suspended from the load-measuring mechanism in place of the specimen. The weights shall be applied in increments and removed in the reverse order. They shall be arranged symmetrically with respect to the weighing platform, so that the center of gravity of the load lies in the vertical line through the center of the platform. The applied load and the indicated load shall be recorded for each test load applied, and the error computed from these data.

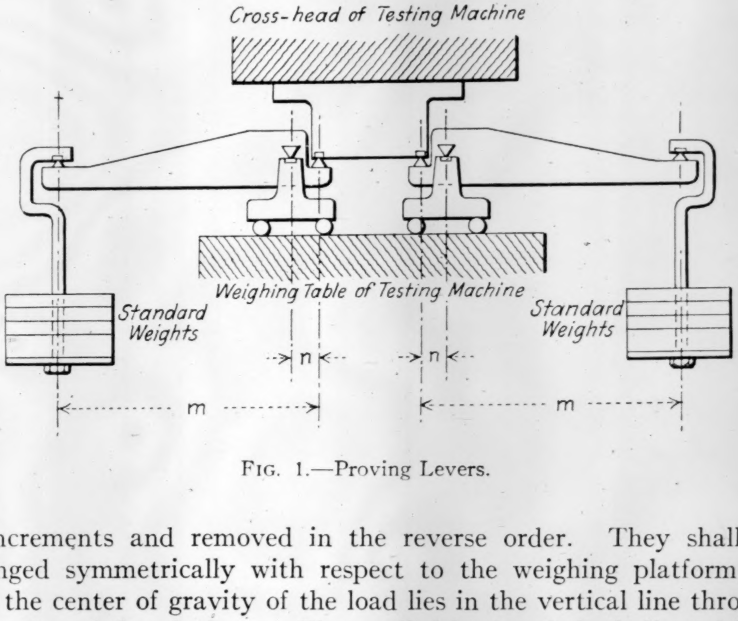
Cross-head of Testing Machine
Weighing Table of Testing Machine
Standard Weights
Standard Weights
n
n
m
m

FIG. 1.—Proving Levers.

NOTE.—The method of verification by standard weights can be used only on vertical testing machines. The total load is limited by the size of the platform and the number of weights available. Often twenty weights of 50 lb. each are used, a total of 1000 lb.

This method of verification is seldom used for any but small testing machines, as the loading range does not include the loads for which large machines are used.

(B) *Method of Verification by Standardized Proving Levers*

Description of Levers.

5. The arrangement of proving levers for verifying testing machines is shown in Fig. 1. The two levers rest on supports on the weighing platform of the testing machine. These supports shall move easily in a horizontal direction, which insures that the forces at each of the knife edges shall be very nearly vertical. The inner knife edges in each lever bear against a suitable block in the movable head of the testing machine. Weight trays or hangers are suspended from each of the outer knife edges and these trays or hangers are loaded with standard weights. The increment of load put on the testing machine by the standard weights is the amount of standard weights multiplied by the lever ratio m/n, Fig. 1.

Specifications of Levers.

6. The knife edges, as well as their supports, shall be of hardened tool steel. The knife edges shall be ground sharp with an angle of 90 deg. The load on any knife edge shall not exceed 7000 lb. per linear inch. The three knife edges in each lever shall be parallel, and their edges shall lie in a plane. Each lever shall have machined surfaces in this or in some parallel plane, upon which a spirit level can be placed.

Verification of Levers.

7. The lever ratio of a proving lever shall be determined by the use of at least three test loads; the amount of weights used shall not be less than the maximum load applied upon one of the arms of a lever in using the levers to verify testing machines. The proving lever shall be balanced over its center knife edge with suitable weight trays suspended from the end knife edges. Standard weights shall then be applied to the trays in three steps, corresponding approximately to 50, 75, and 100 per cent of the weights available, and the proving lever shall then be brought to a balance by the use of small weights and by observations of the freely swinging proving lever. From the weights in the two weight trays the lever ratio shall be computed.

Method of Procedure.

8. The proving levers shall be placed symmetrically in the testing machine to be verified and both levers brought as near a horizontal position as is feasible, after applying each increment of load, by means of the movable head of the testing machine. The testing machine shall be balanced with the levers in place and the weight trays empty. Standard weights shall be applied in increments, half an increment in each tray, and they shall be removed in the reverse order. The weights shall be placed symmetrically on the weight trays, with the center of gravity of the weights over the center of the tray. The applied load and the indicated load shall

be recorded for each test load applied, and the error computed from these data.

NOTE.—The method of verification by standardized proving levers is used, at the present time, only on vertical testing machines. It is often used up to loads of 10,000 lb.

(C) *Verification by Comparison Method*

Description of Comparison Method.

9. When the direct method of verification of a testing machine cannot be carried out (as is the case at present with horizontal testing machines, for example), a comparison method of verification shall be used. In this method the machine to be verified is tested by comparing its indications with the corresponding readings obtained under the same conditions by the use of another testing machine, especially tested and verified, as specified in Section 10. The method of verification by comparison shall be carried out by the use of a series of companion specimens, half of which are to be tested in tension in the machine to be verified, and half of which are to be tested in tension in the especially verified testing machine which serves as a standard machine. The general provisions respecting the application of the test loads and the loading range which are outlined in the direct method of verifying testing machines shall apply to the verification of testing machines by the comparison method, so far as is practicable.

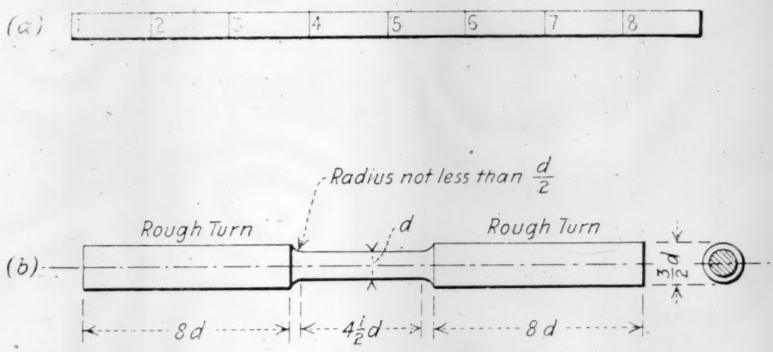

FIG. 2.—Comparison Specimen.
(*a*) Method of Numbering Specimens.
(*b*) Form of Test Specimen.

NOTE.—The method of verification of a testing machine by standard weights (Section 4) and the method of verification by standardized proving levers (Sections 5 to 8) are both regarded as superior to the method of verification by the use of companion specimens. If the results of a verification test of a testing machine by the comparison method fail to agree with the results of a verification by either the standard-weight method or the proving-lever method, the results of the verification by the comparison method shall be discarded.

Requirements for Testing Machines used for Verifying Other Machines.

10. (*a*) A testing machine which is to be used as the standard for verifying other testing machines shall itself be verified by a special test, in which the verification is carried out twice. The loading range shall be determined by the tolerance for new testing machines, namely, ± 1 per cent (Section 14). For the loading range established, the differences in indications found in the two tests of the standard machine shall not exceed 0.25 per cent.

(*b*) In verifying testing machines by the comparison method, corrections shall be applied to the indications of the standard machine and these corrections shall be based on the average correction obtained in the two tests used in its verification.

Test Specimens.

11. (*a*) For each test load, eight or more tension test specimens shall be cut from soft rolled or drawn steel and numbered consecutively, as in Fig. 2 (*a*).

(*b*) The tensile strength of the steel shall be determined by a preliminary test and the sets of specimens for the comparison test shall have such nominal cross-sectional areas as will give, approximately, the loads required. The form of the specimen shall be as shown in Fig. 2 (*b*). The ends may be threaded, or otherwise machined, to fit holders, but it is recommended that those specimens shipped to another laboratory be left with cylindrical ends. The actual value of "*d*" (Fig. 2) for each specimen shall be determined by means of a micrometer.

NOTE.—It should be noted that the standard tension test specimen, 0.5 in. in diameter and having a 2-in. gage length, satisfies the requirements for a specimen for the verification of a testing machine by the comparison method. See 1921 Book of A.S.T.M. Standards, p. 35, Fig. 1.

Method of Procedure.

12. (*a*) The specimens having odd numbers shall be tested in the machine to be verified and those having even numbers in the standard testing machine. The tensile strength only shall be determined.

(*b*) The pulling speed of the movable head of the testing machine when testing verification specimens shall not exceed the speed of the movable head of the testing machine for determining the yield point of the material from which the specimens are made:[1] namely,

GAGE LENGTH, IN.	SPEED, IN. PER MINUTE
2	0.50
8	2.00

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[1] A speed of 0.1 in. per minute would be still better, but would make the verification process a very slow one. The speed of head of the testing machine is the speed measured with the head running free with no specimen in the machine.

with proportional intermediate maximum speeds for gage lengths between 2 and 8 in.

(*c*) When testing verification specimens, especial care shall be taken to maintain the weighing beam of the testing machine in equilibrium as the tensile strength of the specimen is approached. It is recommended that a mark be placed at the middle of the trig loop and that a pointer be placed on the beam for verification tests, and that the pointer be kept as nearly on the mark as possible.

Computation of Error.

13. (*a*) The average tensile strength (in pounds per square inch) of the odd-numbered specimens, multiplied by the nominal area of cross-section, shall be considered a measure of the indicated load and the average tensile strength of the even-numbered specimens, multiplied by the nominal area of cross-section, shall be considered a measure of the applied load. The error shall be computed from these data.

(*b*) If the tensile strength (in pounds per square inch) of any verification specimen varies more than 1 per cent from the mean of the group with which it is tested, its tensile strength shall not be used in computing the error of the testing machine. If more than one specimen in the odd-numbered group or one in the even-numbered group exceeds the allowable variation in tensile strength, all the specimens shall be discarded and another set prepared.

III. TOLERANCES FOR TESTING MACHINES THAT MEASURE LOAD

Tolerances.

14. All testing machines that measure load shall conform to the following tolerances:[1]

(*a*) *New Machines.*—The error for loads in the loading range shall not exceed ±1.0 per cent for new machines or for those which have had any of the knife edges in the weighing mechanism repaired or renewed.

(*b*) *Used Machines.*—The error for loads in the loading range shall not exceed ±1.5 per cent.

Corrections.

15. The indicated load of a testing machine shall not be corrected either by computation or by the use of a calibration diagram to obtain values within the required tolerance.

IV. TIME INTERVAL BETWEEN VERIFICATIONS

Time Interval between Verifications.

16. It is recommended that testing machines, when in constant use, be verified at intervals of six months and, when used intermit-

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[1] It is believed that the tolerances given in this section may be made much smaller when more perfect methods of verification become generally available; and that the tolerances might well be materially reduced if there is available equipment for verifying testing machines by the use of standard weights (Section 4) or by the use of standardized proving levers (Sections 5 to 8).

tently, at intervals of two or three years. Testing machines shall, however, be verified immediately after making repairs or adjustments of the weighing mechanism, and whenever there is reason to doubt the accuracy of the results, without regard to the time interval since the last verification.

V. REPORTS AND CERTIFICATES

Reports. 17. A clear and complete report shall be prepared of each verification of a testing machine. This report shall contain all data necessary to verify the accuracy of the report, and shall be filed for future reference. This report shall state clearly the method of verification used.

Certificates. 18. A certificate giving the maker's serial number and a brief description of the testing machine, the maker's name, the date of verification and the loading range, shall be signed by the person responsible for the maintenance of the testing machine, and this certificate shall be posted in plain view of a person operating the testing machine.

TENTATIVE METHODS
OF
METALLOGRAPHIC TESTING OF IRON AND STEEL.[1]

Serial Designation: E 3 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and until its adoption as Standard it is subject to revision.

ISSUED, 1921; REVISED, 1923.

MACROSCOPIC EXAMINATION.

PREPARATION OF SURFACE.

In order to show up both chemical and crystallin heterogeneity, sections of iron and steel are more or less deeply etched in order to bring out their macrostructure. In this way the persistence of the dendritic structure of castings even after much heat treatment and mechanical working, physical unsoundness such as blowholes, gas cavities, porosity, fine internal cracks and flakes, discontinuities of structure such as found in welding, flow of metal as in riveting, punching, hot pressing and forging, etc., are brought out.

Suitable sections are cut, smoothed and then ground on various grades of emery paper in order to obtain a smooth flat surface. In some cases it is necessary to continue polishing through No. 0. and No. 00. French Emery Papers. The sample ought to have a surface free from grease and dirt; if necessary it is then freed from all grease by cleaning with gasoline and then alcohol when it is ready for immersion in the solution.[2]

SOLUTIONS USED IN ETCHING.

Macroscopic etching of iron and steel was used as early as 1783 by Bergman. Many different solutions have been used and many of them are given by Campbell,[3] and more recently by Rawdon.[4]

Of the following solutions 1 (*a*) and 2 are recommended.

1. To show up segregation and the like:

(*a*) Hot concentrated hydrochloric acid used at about 100° C. A deep etched specimen may be printed with printer's ink.

(*b*) Etching for 4 to 5 hours with 5-per-cent picric acid in alcohol.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.

[2] For large sections various methods have been devised depending on the material. Surface grinding when carefully done gives excellent results.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part II, p. 96 (1915).

[4] The Structure and Related Properties of Metals. Bureau of Standards *Circular C 113*.

2. To show up variations in crystallin structure as well as segregation:

One to two grams of ammonium persulfate in 10 cc. of water. This is probably the best reagent for developing this phase of the structure in iron and steel.[1]

3. To show up the distribution of phosphorus:

Various reagents containing copper chloride are used. The copper coats those portions which are low in phosphorus and leaves the high phosphorus areas bright. It has recently been shown that nickel and other alloys give similar effects, also that oxide of iron acts in the same way. The accompanying list shows the various solutions which have been recommended:

Heyn.—Copper-ammonium chloride	10 g.
Water	100 cc.

A somewhat weaker solution is better, the specimen being etched two or three times in fresh solution if necessary. The liquid is gently agitated. The coating of spongy copper forming on the face of the specimen is easily removed with a swab of wet cotton. Portions high in carbon, sulfur and phosphorus will have darkened. If the copper film adheres, a 0.5-per-cent solution of ammonium persulfate will facilitate its removal.

Stead.—$CuCl_2$	10 g.	Dissolve salts in smallest possible amount of hot water and make up to 1000 cc. with absolute alcohol.
$MgCl_2$	40 g.	
HCl	10 cc.	
H_2O	20 cc.	
Alcohol to	1000 cc.	

For small specimens the reagent is applied drop by drop until structure is developed. The specimen is then washed with boiling water and then alcohol.

Another method is to wash off the deposited copper with ammonia and so increase the contrast.

Le Chatelier and Lemoine.—	$CuCl_2$	10 g.
	$MgCl_2$	40 g.
	HCl	20 cc.
	H_2O	180 cc.
	Alcohol	1000 cc.

Applied like Stead's reagent. Contrast can be increased by electrolysis, using a single battery cell, keeping the current below 50 milliamperes.

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[1] Rawdon, "Macro-etching with Ammonium Persulphate," *Scientific Paper No 402*, Bureau of Standards (1920).

Rosenhain and Haughton.—

Fe_2Cl_6	30 g.
HCl	100 cc.
$CuCl_2$	10 g.
$SnCl_2$	0.5 g.
H_2O	1000 cc.

The copper adheres firmly. Pearlite areas remain bright. Ferrite darkened by deposited copper, the purest parts darkening the fastest. Pitting can be avoided by diluting the reagent.

LeChatelier and Dupuy.—

Ethyl alcohol	100 cc.
H_2O	10 cc.
$CuCl_2$	1 g.
Picric acid	0.5 g.
HCl (concentrated)	1.3 to 2.5 cc., varying with material.

Oberhoffer.—

Ethyl Alcohol	500 cc.
H_2O	500 cc.
$SnCl_2$	0.5 g.
$CuCl_2$	1.0 g.
Fe_2Cl_6	30 g.
HCl	50 cc.

Humfrey.—Emery paper finish may be used for specimen.

Copper ammonium chloride	120 g.
HCl (concentrated)	50 cc. (±)
H_2O	1000 cc.

The addition of HCl causes the copper deposit to adhere. Etching is therefore started with the neutral solution and continued until all traces of the scratches have disappeared. Then in successive applications the acidity of this solution is gradually increased up to the maximum. Alloy steels etch better with solutions of weaker acidity. After wiping away the deposited copper and drying, the surface is lightly rubbed with fine emery paper and the relief portions brought out in strong contrast. The section may be printed with ordinary printer's ink applied to the surface by means of a roller.

Dickenson.—First etch with 10-per-cent HNO_3. Then re-etch with:

Fe_2Cl_6	40 g.
$CuCl_2$	3 g.
HCl	40 cc.
H_2O	500 cc.

4. For etch tests to distinguish between wrought iron and steel, to develop the structure of welds, etc., the following rapidly-acting reagents are recommended, the percentages given being by volume:

(*a*)	Hydrochloric acid (sp. gr. 1.19)	10 per cent
	Sulfuric acid (sp. gr. 1.84)	30 "
	Water	60 "
(*b*)	Nitric acid (sp. gr. 1.42)	25 "
	Water	75 "

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Stead, *Idem,* 1918, Vol. I, p. 408.
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Le Chatelier and Dupuy, *Revue de Mettalurgie,* 15, p. 127.
Oberhoffer, *Stahl und Eisen,* 1916, 36, Vol. I, p. 798.
Charpy and Bonnerot, *Comptes Rendus,* 1914, 165, p. 536.
Humfrey, *Journal,* Iron and Steel Inst., 1919, Vol. I, p. 273.
Dickenson, *Idem,* p. 294.
Howe, "Metallography of Steel and Cast Iron," p. 601.

METHODS FOR INDICATING DISTRIBUTION OF SULFUR.

The distribution of sulfur is usually shown by the sulfur print method. A solution of 2 to 3 cc. of concentrated H_2SO_4 in 100 cc. of water is used to moisten a sheet of matt-finish photographic paper. The specimen with its surface smoothed either with a fine file or grinding wheel is pressed firmly on the paper on which a brown mark indicates the sulfur-rich areas. About 60 seconds is usually sufficient to give a good print. The paper is then washed and fixed in hyposulfite solution.

With larger sections the paper is placed on their polished surface with care so that no air pockets occur. If a very dilute solution is used and a longer "etch" several prints can be obtained. Fresh solution can be added with absorbent cotton should the paper tend to become dry.

REFERENCES.

R. Baumann, *Metallurgie,* 1906, p. 416.
Stead, "Sulphur and Iron," Staffordshire Iron and Steel Institute, March, 1908.
Hatfield, "Cast Iron," p. 71, shows sulfur prints of pig iron.

METHODS USED FOR THE LOCATION OF MINUTE CRACKS BEFORE DEEP ETCHING.

Considerable differences of opinion have arisen as to the meaning of the results obtained by deep etching in transversely fissured rails, etc., because the presence of cracks in the material previous to etching had not been demonstrated. The following method, however, can be used to locate them. The sample after careful polishing is magnetized and then immersed in kerosene or a similar liquid containing very fine iron dust in suspension. The particles of iron dust collect upon the face of the specimen and orient themselves to correspond to the shape of the cracks because of discontinuity in the metal which causes a change in the density of the magnetic flux. The samples are then washed in clean kerosene to remove as much as possible of the excess iron dust which clings to the surface.[1]

According to several authorities their existence has been proven by annealing the specimens prior to etching, because a pronounced decarburized area then occurs around these cracks.

METHOD OF PHOTOGRAPHING.

The camera should be arranged so that the specimen is illuminated by vertical light. After certain kinds of etching, *e. g.*, ammonium persulfate, the surface should be immersed in water, alcohol or light oil. For large specimens the surface may be covered with oil or glycerin.

PRINTING THE SURFACE.

The surface obtained by deep etching may be printed with printer's ink applied with a roller. The printing can be done on a glossy paper in a letter press. For small samples of wrought iron deeply etched a reproduction can be made using an ordinary ink pad and applying the specimen as in block printing.

MICROSCOPIC EXAMINATION.

LOCATION OF TEST PIECES.

The location of the test piece for microscopic examination is of prime importance. In the case of a casting of steel or cast iron, the section ought to be cut perpendicular to the surface so as to show the variation of structure from the outside to the interior. In the case of forged and rolled metal both cross and longitudinal sections should be examined, their location being determined by the nature of the forging etc. For crankshafts definite locations are given with reference to the tension test specimens. For guns, tangential specimens are required and for microstructure these should be cut parallel to the axis, etc. No one specimen is of necessity representative. The usual method of taking a cross-section from rods and bars while showing segregation of the constituents fails to reveal the usual lamination in such material for which a longitudinal section is necessary. The location of test specimens may be determined by a preliminary macroscopic examination.

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[1] Rawdon and Epstein, *Technologic Paper No. 165*, Bureau of Standards (1920).

In defective material, the sample should be cut adjacent to the fracture or defect. When necessary the fracture can be protected during grinding and polishing by coating it with a heavy deposit of electrolytic copper, molten lead-tin solder or a mixture of litharge and glycerin. For hardened steel and other material liable to be tempered, fusible metals such as Rose's or Wood's alloys may be used.

METHOD OF POLISHING.

The method used for polishing specimens will depend primarily on the material to be examined and on the polishing equipment. In general, samples should not be over 1-in. square and their thickness should be less than the smallest dimension of the polished surface; otherwise there is a tendency to round off the edges during the process.

The softer material can be cut with a saw while harder metal may be cut with an emery disk or broken off with a hammer. A flat surface is at first obtained either by rubbing on a file held in a vise or by grinding on an emery wheel. In both cases it is necessary to avoid tearing the surface of the metal or causing it to flow. Perfectly smooth surfaces can be obtained by commercial surface-grinding machines.

Having obtained a flat surface in this way, the sample is next rubbed down on a series of emery papers, usually starting with No. 00 Commercial followed by Nos. 0 and 00 French Emery. These papers may conveniently be mounted on revolving disks. Rubbing on one paper is stopped as soon as the scratches from the last operation have been taken out. From the No. 00 French Emery the specimen may be taken to a revolving disk covered with broadcloth, preferably running in a horizontal position at such a speed that the polishing powders are not unnecessarily thrown off. For ordinary work, two such disks will be sufficient, the first armed with well-washed carborundum, 65 or a similar grade, while the second may be armed with well-washed alumina This is preferable to rouge because it is much cleaner.

To obtain a fine polish it is a mistake to try to save time by hurrying through the papers because if this is done, when the specimen is etched, innumerable fine lines will be revealed in the ferrite. In some cases the appearance of the ferrite is actually blurred because the metal distorted in the grinding and by the coarse grades of emery has not been subsequently removed. Under no conditions should buffing be tried, because this causes an actual flow of the metal and the structure is thereby obliterated.

No general rules can be laid down as to the method to be pursued, but common sense will tell what is right and what is wrong. For example, in grinding on the emery wheel a copious flow of water must be maintained, otherwise the surface of the sample will heat up and the structure of the metal will be modified thereby.

For material of small size, such as sheet and wire, numerous methods of mounting have been devised. For wire, various mounting media such as wax, a mixture of litharge and glycerin, fusible metals and the like can be used in a small brass container. For sheet metal, a pack can be built up of pieces of the sample with alternate layers of red fiber board, bakelite or other resistant material, the whole held together by two brass end pieces and two screws. The whole can then be polished down.

METHODS OF ETCHING.

The sample ought to be examined as polished in order to show up the non-metallic inclusions as well as cracks and other defects. In order to show up the structure of the metallic matrix various etching reagents have been used depending on the material being examined. The accompanying list gives the best of these reagents. For general work a 4-per-cent solution of picric acid in ethyl alcohol is recommended. This darkens the pearlite in steel and leaves the ferrite or cementite bright as the case may be. Long etching with picric acid in alcohol will develop the grain structure in very low carbon steel and in wrought iron. This may be done more rapidly with a 2 to 4-per-cent solution of nitric acid in ethyl alcohol (95-per-cent). For showing up pearlite alone, picric acid in absolute alcohol is best.

To distinguish between ferrite and cementite in high-carbon steels, the usual method is to boil in the sodium picrate solution, which darkens the cementite.

For hardened and tempered steel, picric acid may be used, but after etching, washing under the tap, and flooding with alcohol, the specimen should be dried by an air blast or if this is not available by shaking it in air. If the usual method of mopping on a soft towel be tried, the etching film will be spoiled.

For the study of hardened and tempered steels under high magnifications other reagents have been devised such as those of Kourbatoff.

For distinguishing between cementite and phosphide of iron in cast iron, either heat tinting or boiling with sodium picrate may be used, as recommended by Matweiff. This attacks the iron phosphide but leaves the cementite unattacked.

For revealing the segregation of the phosphorus in steel, various reagents have been used depending on the deposition of copper from a copper chloride solution, as given in the accompanying list of reagents.

Certain alloy steels, especially those high in the alloying elements, are very resistant to etching. For these special solutions have been devised such as ferric chloride for high-nickel material, caustic soda solution of hydrogen peroxide, etc., for high-speed steels.

In many cases after etching, the ferrite or cementite may be found to be more or less stained or colored. This can often be remedied by a light repolish on a chamois-skin pad. While this brightens up the ferrite or cementite, as the case may be, it markedly alters the appearance of the pearlite, giving it an abnormal structure, and therefore when this method is used, photographs should be so marked. The accompanying lists of reagents are commonly used.

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Kerns, Foundry Data Sheets, June 1 and 15, 1920. Etching Solutions for Iron and Steel.

Kourbatoff, *Revue de Metallurgie*, 2, p. 169 (1905). Contribution a l'Etude Metallographique des Aciers Trempes.

Kourbatoff, *Revue de Metallurgie*, 3, p. 648 (1906).

Pamphlet No. 403, U. S. N. Bureau of Ordnance, October, 1916.

REAGENTS FOR ETCHING.

(*a*) SOLUTION FOR NORMAL IRON AND STEEL.

	(*a*)	(*b*)
Picric acid (*Igevsky*).—	4 g. picric acid.	5 g. picric acid.
	95 cc. ethyl alcohol, absolute.	100 cc. ethyl alcohol (95-per-cent).

Nitric acid.— 5 cc. HNO_3 (concentrated).
95 cc. ethyl alcohol (95-per-cent).

Iodine.—1.25 g. I.
1.25 g. KI.
1.25 cc. H_2O.
to 100 cc. alcohol.

Hydrochloric acid (*Martens and Heyn, 1904*) (*hardened steel especially*).—
1 cc. HCl (sp. gr. 1.19).
100 cc. alcohol.

May dilute to 500 cc. water: 1 of HCl, using very weak current.

(*b*) SOLUTIONS FOR HARDENED STEEL.

Kourbatoff's Solutions.—

1. A. Solution.— 4 cc. HNO_3.
96 cc. amyl alcohol.
5 min., troosto sorbite brown, austenite yellow, martensite white.

2. C. Solution.—1 part amyl alcohol }
1 " ethyl " } (1).
1 " methyl " }
1 " of 4-per-cent HNO_3 in acetic anhydride (2).
Colors troostite and troosto-sorbite. Mix 1 and 2 just before using.

3. 2 parts methyl alcohol.
2 " ethyl "
2 " amyl "
1 " butyl "
3 " of 4 per cent HNO_3 in acetic anhydride.
For troostite.

4. 4-per-cent HNO_3 in methyl alcohol to which 1/10 its volume of 4-per-cent picric acid in ethyl alcohol is added.
Colors austenite, martensite and troosite differently.

5. D. Solution.—1 volume of 4-per-cent HNO_3 in ethyl alcohol.
3 volumes saturated solution of nitrophenol in ethyl alcohol.
10 min. colors troosto-sorbite and martensite needles.

6. B. Solution.—1 volume of saturated solution of ortho-nitrophenol in alcohol.
2 volumes of 20-per-cent HCl in amyl alcohol.
Differentiates the various constituents.

7. 1 volume of HNO_3 in alcohol
3 volumes of saturated solution of nitraniline.
Colors troostite, troosto-sorbite and martensite needles.

Benedicks.—5-per-cent meta-nitrobenzol sulfonic acid in alcohol 0.15″ darkens martensite more than austenite.

(*c*) SOLUTIONS FOR CARBIDES, ETC.

Kourbatoff.— 2 g. picric acid.
98 cc. of 25-per-cent NaOH in water.
Used boiling 5 to 10 min. Cementite colored. Also Fe_nW, Fe_2W_2C, etc., in tungsten steels while WC is unattacked. Ferrite unattacked.

Matweieff.—Neutral sodium picrate washed several times with distilled water.
Solution used boiling. 20 min. Iron phosphide attacked, cementite unattacked.

Yatsevitch.—10 cc. H_2O_2 (commercial).
20 cc. of 10-per-cent NaOH in water.
10–12 min. For high speed steel. Use fresh. Tungsten carbide darkened.

Hilpert and Colver-Glauert.—3 to 4 per cent of a saturate solution (aqueous) of SO_3 in alcohol or water.
7 sec. to 1 min. For non-pearlitic steels and pig iron.

Murakami.—10 g. potassium ferricyanide.
10 g. potassium hydroxide.
100 cc. water.

Use hot. Distinguishes between carbide and tungstide in high speed and in tungsten steels.

(*d*) SOLUTIONS FOR ALLOY STEELS.

Ferric chloride.—Fe_2Cl_6, 5 g.
HCl 50 cc.
Water 100 cc.

Used for austenitic nickel steels.

Electrolytic.—Aqueous solution of 0.5-per-cent NaOH with very weak current. On 110 volt circuit use two 4 c. p. lamps in series, connected with two wire terminal (platinum wire preferable). Flood specimen's surface with solution. Make contact with one wire at side and dip the other with the solution, moving it around to obtain uniform etch. Used for stellite, high chrome, etc.

METHODS FOR IDENTIFICATION OF NON-METALLIC INCLUSIONS.

Stead.—Dilute H_2SO_4 (1 : 3 H_2O). Bubbles from sulfides, none from silicates.

Law.—Uses an acid solution of lead or cadmium salt in gelatin. The sulfides form deep brown or yellow stain of cadmium or lead sulfide.

Electrical etching solution: Distilled water with 0.002-per-cent ammonium chloride or caustic potash solution used boiling. After a few minutes wash and dry with alcohol.

MnS unaltered.
Oxide completely removed.

Matweieff.—Action of hydrogen at high temperatures.
- Oxides (MnO FeO)—reduced.
- Silicates—unaffected.
- Sulfides—unaffected.

Action of vapor of water at high temperatures.
- Oxides—attacked.
- Silicates—unattacked.
- Sulfides—unattacked.

Action of organic acids.
- Oxides—unattacked.
- Silicates—unattacked.
- Sulfides—attacked.

Distinction between FeO and MnO.
- Reduction by hydrogen—repolished.
- Dilute alcohol solution of $FeCl_3$.
  - If colored deep—MnO with some FeO.
    MnO alone is not reduced.
  - If colored feebly—FeO.

Distinction between FeS and MnS.
- FeS—colored by solution of tartaric acid.
- MnS—very feebly colored.

Rohl.—Sulfides 1-per-cent acetic, citric, oxalic or picric acid in water.

FeS always more readily blackened in one minute. MnS blackened slightly after 45 seconds.

Picric acid gives most uniform results.

1-per-cent acetic or picric acid in ethyl alcohol can be used.

Etching by picric acid (4 g. acid + 100 cc. amyl alcohol then by dilute HNO_3) (4 cc. + 100 cc. amyl alcohol) then by concentrated hot NaOH solution. Dark brown color due to sulfides.

Sodium acetate 2 per cent aqueous—1 minute.

FeS—brownish tint.

MnS—very light.

Reduction Tests:

(1) $HgCl_2$ solution.

Sulfides covered with Hg especially FeS.

Repolishing (softly) FeS—corroded, MnS—not corroded.

(2) $AgNO_3$ solution. (3-per-cent solution boiling.)

FeS—uniform violet blue.

MnS—dove gray slightly darkened.

Repolishing:

FeS—reddish violet.

MnS—blue gray.

Rohl's Method of distinction:

(1) Organic acid 1 per cent in ethyl alcohol with 5 minutes etching.

FeS darkens more than MnS.

(2) A short preliminary etching. With 1 per cent picric acid in ethyl alcohol followed by tempering to dark yellow.

FeS—a beautiful dark blue to reddish violet.

MnS—dull gray to bright white.

SULFIDES.

McCance.—

Whiteley's Reagent	5 g. gelatin + 20 cc. H_2O, soak for one hour and add 15 cc. glycerin. Heat till clear, add 0.05 g. tartar emetic in 1 cc. H_2O, filter and add 1 cc. dilute H_2SO_4. Apply warm. Yellow ring forms around sulfides.
McCance's Reagent	Replace tartar emetic by 0.1 g. $AgNO_3$. Black stain indicates sulfide.

FOR SILICATES AND OXIDES.

McCance.—

A.	HF	2 cc.	For steels, about 3 sec. darkens sulfides, and silicates. Oxides unattacked.
	absolute alcohol	98 cc.	
B.	HF	8 cc.	
	H_2O	42 cc.	
	Alcohol	50 cc.	

Comstock.—Uses boiling alkaline picrate of soda. MnS blackened and roughened. Silicates and oxides unaffected.

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Stead, *Iron and Steel*, IX, p. 105.

Law, *Journal*, Iron and Steel Inst., II, 94 (1907).

Matweieff, *Revue de Metallurgie*, VII, p. 447.

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Comstock, *Transactions*, A. I. M. E., LVI, 553 (1916).

MEANS FOR THE IDENTIFICATION OF NON-METALLIC INCLUSIONS.

As Polished

FeS.	Brownish yellow.
MnS.	Slate blue, smooth.
FeS_xMnS_y.	Slate blue to brown, may show duplex structure.
FeO.	Slate blue, rough, a little darker than MnS.
MnO.	Similar.
Mn—Silicate.	Greenish tinge, smooth and greasy.
Fe—Silicate.	Black and greasy.
Al_2O_3.	Tiny hard rounded grains, never elongated by rolling, etc.
Sand Grains.	Angular form, convex side, greasy appearance standing in high relief.
Titanium nitride or cyanonitride.	Pink or yellow cubic crystals.

	SULFIDES.	OXIDES.	SILICATES.
H_2SO_4 (1 : 3 H_2O)	Gas bubbles.	No action.	No action.
Pb or Cd. salt in gelatin.	Brown or yellow stain.	" "	" "
McCance's Reagent, $AgNO_3$ in gelatin.	Black stain.	" "	" "
Acetic, citric, oxalic, etc.	Attacked.	" "	" "
Boiling sodium picrate.	Black and rough.	" "	" "
H or H_2O at 600° C.	No change.	Reduced or attacked.	" "
2 cc. HF in alcohol, 3 sec. etch.	Darkened.	No action.	Darkened.
Electrolysis (0.002-per-cent NaOH).	No change.	Removed.	No change.

	FeS	MnS
As polished	Brown-yellow.	Slate blue—smooth.
Tartaric acid	Colored.	Colored, less.
1-per-cent picric alcohol. 5 min	Blackened.	Less so.
Ditto. Heat tint to dark yellow	Blue-violet.	Dull gray white.

	FeO	FeO_xMnO_y	MnO
H at 600°	Reduced.	Reduced.	Unreduced.
Electrolysis (0.002-per-cent NaOH)	"	"	"
Alcohol Fe_2Cl_6 solution after electrolysing and repolishing	Feeble color.	Deep color.	Not reduced.

TENTATIVE METHODS
OF
METALLOGRAPHIC TESTING OF NON-FERROUS METALS AND ALLOYS[1]

Serial Designation: E 5 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society, and is subject to revision.

Issued, 1923

MACROSCOPIC EXAMINATION

In order to show up both chemical and crystallin heterogeneity, sections of metals and alloys should be more deeply etched than for microscopic examination. The dendritic structure in castings, dendritic shrinkage cavities, blowholes and other porosity, the flow of metal due to cold working, etc., are brought out.

After cutting the section, it is filed or ground smooth and flat, then rubbed on various grades of emery paper down to No. 00 French, so that all effects of surface cold working due to cutting are eliminated. After cleaning the surface of all grease it is ready for etching.

ETCHING SOLUTIONS

For macroscopic etching, most of the reagents used for microscopic examination may be used, but the time of etching is usually much longer. Those solutions which give maximum grain contrast are usually to be preferred.

For copper and its alloys, a 50-per-cent aqueous solution of nitric acid is recommended. Also an ammoniacal solution of copper ammonium chloride is very satisfactory.

The specimen is either immersed in the solution or flooded with it until the structure shows up strongly. It is then well washed with running water, flooded with alcohol and dried. If the structure is to be recorded, it should be photographed immediately. The surface may be preserved for reference by covering with a thin coat of brass lacquer (a solution of gun cotton in Amyl Acetate) or similar preparation.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.

For aluminum and its alloys, a 10-per-cent aqueous solution of sodium hydroxide is recommended.

For lead and its alloys, 10 per cent of nitric acid in water is recommended. For lead ingots, acetic acid gives excellent results.

MICROSCOPIC EXAMINATION

LOCATION OF TEST PIECES

In the case of castings, the sections ought to be cut perpendicular to the surface and show the variation of structure from outside to center. For rods, sheet, etc., transverse, longitudinal and frequently oblique sections should be examined. For large forgings, the threaded ends of the tension test pieces can usually be used by cutting a longitudinal section about one inch in length. No one specimen is of necessity representative. As in iron and steel, the usual method of taking a cross-section from rods and bars while showing segregation, fails to reveal lamination. Surface sections of sheet metal are usually taken, but for cold-worked metal, transverse, longitudinal and frequently oblique sections are also necessary.

For material of small size, the methods of mounting recommended for iron and steel can be used as described in the Tentative Methods of Metallographic Testing of Iron and Steel (Serial Designation: E 3 - 23 T) of the American Society for Testing Materials.[1]

METHOD OF POLISHING

The methods recommended for iron and steel as described in the Tentative Methods of Metallographic Testing of Iron and Steel (Serial Designation: E 3 - 23 T) of the American Society for Testing Materials[1] are applicable for the harder alloys. For soft metals and alloys, emery wheels cannot be used. The sample is rubbed on a file held in a vise, care being taken that the surface is cut and not torn. The file must be kept free from embedded particles of metals or the surface is bound to be torn.

In using the emery papers, only very little pressure may be used or the surface is apt to flow. For soft metals, rubbing by hand is recommended. If revolving disks are used, low speed must be maintained to prevent spoiling the surface. From the No. 00 French paper the specimen may be taken to a revolving disk covered with broadcloth and armed with well-washed alumina. Again, for soft metals, if the pressure is too great the surface is apt to be spoiled. Buffing cannot be used. For very soft metals, such as lead and some of its alloys, even the most careful polishing leaves a film of "flowed" metal. Such samples can be etched fairly deeply with 10 per cent of nitric acid in water and then given a very light repolish with alumina, the surface of the disk being kept very moist. It is then washed free from polishing powder and dried with alcohol.

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[1] See p. 919.

METHODS OF ETCHING

The sample is first examined for non-metallic inclusions, cavities and the like. The structure is then developed by etching with a suitable reagent, a list of which is given below. No one reagent can be said to be the best for any alloy or group of alloys. Cast metal behaves quite differently from both hot and cold-worked or annealed material.

For copper and its alloys a 50-per-cent aqueous nitric acid solution is recommended. The sample is immersed until the structure shows up, then washed with water and dried with alcohol. This reagent, however, is liable to cause pitting.

For wrought brass, bronze, German silver, etc., the best reagent is ammonia and hydrogen peroxide. About 10 cc. of strong ammonia are placed in a watch glass, 1 or 2 cc. of peroxide (3.6-per-cent) added and applied to the surface of the specimen with a small wad of cotton, rubbing gently till the grain structure appears.

For cast gun metal, this method shows up the coring of the dendrites but the eutectoid has little contrast with the saturated parts of the alpha. If the sample is then flooded with Grard's Solution No. 1 until the alpha darkens slightly, the eutectoid still remains bright blue-white and shows up in marked contrast.

Nickel and its alloys frequently show a peculiar pitting. If a 50-per-cent aqueous nitric acid solution be used, small pits appear with colored rings or halos. Merica's nitric-acetic acid gives much better results.

For wrought nickel alloys, concentrated hydrochloric acid is recommended. The action is very slow but the contrast is excellent.

The etching characteristics of copper and of nickel alloys are thoroughly dealt with by Rawdon and Lorentz.

For aluminum and its alloys sodium hydroxide shows up the grain structure but is liable to cause roughening. The weaker solution is recommended for details of structure and may be further diluted.

The harder constituents usually show up as polished, *e. g.*, Si, $FeAl_3$, $CuAl_2$, $NiAl_3$, and Mg_2Si. To differentiate between them, the last three solutions can be used.

The white metals are usually easy to etch if properly polished. For the lead-tin alloys, however, the usual methods do not work so well. It is better to etch rather deeply with nitric acid and then very lightly repolish on a chamois skin pad until the structure shows up in marked contrast.

REAGENTS FOR ETCHING

(*a*) Solutions for Copper and Copper Alloys

Nitric Acid.—50 cc. nitric acid (concentrated)
50 cc. water

Ammonia.—10 cc. ammonia (concentrated)
1 cc. hydrogen peroxide (Marchand)

Grard No. 1.—5 g. ferric chloride
50 cc. hydrochloric acid
100 cc. water

Grard No. 2.—19 g. ferric chloride
6 cc. hydrochloric acid
100 cc. water

Ammonium Persulfate.—10-per-cent aqueous solution made just before use. This solution is improved materially by the addition of a few drops of ammonia just before using.

Heyn's Solution.—5 g. copper-ammonium chloride
120 cc. water
Add ammonia until precipitate which forms redissolves

(*b*) Solutions for Nickel, Monel Metal, Cupro-nickel

Merica's Solution.—50 cc. of 70-per-cent nitric acid
50 cc. of 50-per-cent acetic acid

International Nickel Co.—20–40 cc. nitric acid
40–30 cc. 75-per-cent acetic acid
40–30 cc. acetone

Hydrochloric Acid.—(Concentrated)

(*c*) Solutions for Aluminum and its Alloys

Caustic Soda No. 1.—2 g. sodium hydroxide
100 cc. water

Caustic Soda No. 2.—10 g. sodium hydroxide
100 cc. water

Alcoholic Nitric Acid.—10 cc. nitric acid (concentrated)
90 cc. alcohol
Shows up Mg_2Si.

Hydrofluoric Acid.—1-per-cent aqueous solution
Etches $NiAl_3$.

Nitric Acid.—25-per-cent aqueous solution

Nitric Acid.—For copper alloys, used hot, colors $CuAl_2$ brown, while $FeAl_3$ and $NiAl_3$ are unattacked.

(*d*) Solutions for White Metals (Lead, Tin or Zinc Base)

Nitric Acid.—2-per-cent alcoholic solution. For tin-rich alloys

Nitric Acid.—5-per-cent aqueous solution. For lead-rich alloys

Hydrochloric Acid.—5-per-cent aqueous solution. For zinc-rich alloys

The above list gives the principal reagent used for etching the chief commercial alloys. Numerous other methods have appeared in the literature, each worker apparently preferring to develop his own method. The papers by Hudson, Czochralski and Guertler covering etching reagents enumerate most of the ones which have had any vogue. Amongst these less used reagents the following may be mentioned:

Gold, Platinum, etc.—Aqua regia
Zinc (Timofeeff).—94-per-cent nitric acid, 6-per-cent chromic acid — A few drops added to 100 cc. of water before use
Tin.—5-per-cent alcoholic solution of hydrochloric acid
Magnesium and its Alloys.—2-per-cent nitric acid in water, 10 sec.
Tungsten.—(1) Boil in ammonia and hydrogen peroxide, or hydrogen peroxide alone.
(2) Electrolytic etch. 15-per-cent NaOH. 20 milliamperes per square centimeter. About 5 minutes.
(3) 2.5-per-cent water solution of potassium ferrocyanide to which a few drops of ammonia are added just before use. Broadcloth or rubber is moistened with the solution and the specimen gently polished on the surface so prepared.

ELECTROLYTIC ETCHING

Electrolytic etching has been advocated by many workers, notably Le Chatelier, for brass and other alloys. The newer methods, as, for example, ammonia with hydrogen peroxide give better results. For certain materials however, electrolytic etching gives excellent results, especially where the samples are very resistant to ordinary etching reagents: for example, tungsten, certain of the nickel chromium alloys, white gold, etc. A simple method is to connect two short platinum wires to the electric light circuit of 110 volt (direct current) through a four-candle-power lamp. Place the specimen on the anode wire so that its upper surface is perfectly level. Drop on enough dilute sodium hydroxide to cover the whole surface and then dip the cathode wire into the electrolyte. In order to get a uniform etch, the end of the wire should be bent at right angles and moved back and forth above the surface of the specimen to be etched. As soon as the structure is visible to the eye, the sample may be washed and dried in alcohol in the usual way. This gives a quick although somewhat rough and ready method but one which usually works very well.

The specimen is held face downwards by a flexible clip attached to the positive connection. The electrolyte is placed in a suitable dish in which the negative pole is immersed. The electrolyte surface is raised until it wets the surface of the specimen and then lowered slightly so as to produce a surface tension contact between the specimen and the solution. The results are very much superior to the old method of complete immersion of the specimen.

REFERENCES

Rawdon and Lorentz, "Metallographic Etching Reagents I. For Copper," U. S. Bureau of Standards *Scientific Paper No. 399.*

Rawdon and Lorentz, "Metallographic Etching Reagents II. For Copper Alloys, Nickel and the Alpha Alloys of Nickel," U. S. Bureau of Standards *Scientific Paper No. 435.*

Comstock, "Non-Metallic Impurities in Brass and Bronze," *Transactions*, Am. Inst. of Mining and Metallurgical Engrs., Vol. 60, p. 38 (1919).

Hudson, "Etching Reagents and Their Applications," *Journal*, Inst. of Metals, Vol. XIII, p. 193.

Czochralski, "Etching Phenomena and Reagents," *Stahl und Eisen*, 35 (2), pp. 1073 and 1129 (1915).

Guertler, "Etching Reagents, "*Zeitschrift für Metallkunde*," Vol. XII, p. 44 (1920).

TENTATIVE DEFINITIONS OF TERMS RELATING TO METHODS OF TESTING[1]

Serial Designation: E 6 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

Tension.—The condition which exists in a body subjected to forces which tend to pull the body apart.

Compression.—The condition which exists in a body subjected to forces which tend to bring closer together the particles of the body.

Shear.—The condition which exists in a body subjected to forces which tend to cause two contiguous parts to slide relatively to each other in a direction parallel to their plane of contact.

Flexure.—The condition which exists in a body subjected to forces which tend to change the curvature of the axis of the body.

Torsion.—The condition which exists in a body subjected to forces which tend to cause rotation about the axis of the body of a cross-section with reference to a contiguous cross-section.

Stress.—The intensity per unit area of the internal force, which, in the presence of forces causing a change in the form of a body, tends to hold the particles in their original relation and to preserve the integrity of the body. Stress is measured in pounds per square inch (kilograms per square millimeter).

NOTE.—In examining the definitions given in various authoritative text-books two definitions of the term "stress" were found. Text-books in physics and some European text-books in mechanics of materials gave a definition substantially as above. American text-books in engineering mechanics define stress as a *force*, measured in *pounds*. They call the intensity of force (pounds per square inch) "unit stress," "intensity of stress," or "fiber stress." This use of the term stress is illustrated by the "stress sheet" of the bridge engineer which gives *forces*, measured in pounds.

In view of the fact that even in engineering text-books the term "stress" is often used to denote intensity of force per unit of area, and in view of the fact that the physicists' definitions involve somewhat simpler terms, the physicists' definitions have been followed in these standards.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. H. F. Moore, Chairman of Sub-Committee, of Committee E-1, on Mechanical Testing of Materials, University of Illinois, Urbana, Ill.

These definitions, when adopted as Standard, will supersede the definitions of terms appearing in the present Standard Methods of Mechanical Testing of Metallic Materials (Serial Designation: E 1 - 18), 1921 Book of A.S.T.M. Standards.

While it is important to have a clear definition for the term "stress" it is even more important to keep clearly in mind the *units* used in computations and test data for materials of construction. In fact, if the units are always given, there can be no misunderstanding as to the sense in which the term "stress" is used.

There are three kinds of stress: tensile, compressive, and shearing. Flexure involves the combination of tensile stress and compressive stress. Torsion involves shearing stress.

Strain.—The change per unit of length in a linear dimension of a body, which change accompanies a given stress. It is measured in inches per inch of length (millimeters per millimeter).

NOTE.—In American engineering text-books the term "strain" is used in the sense of total deformation and is measured in inches. Change of dimension per unit length is called "unit-strain," or "unit deformation." As in the consideration of the term "stress," the definitions given in text-books in physics have been followed.

Under tensile stress or compressive stress, strain is measured along the dimension under consideration. Shearing strain is measured at right angles to the dimension under consideration. In torsion tests, which involve shearing stress, it is customary to measure the angle of twist, which may be translated into terms of strain.

A Stress-Strain Diagram.—A diagram plotted with values of stress as ordinates and values of strain as abscissas.

NOTE.—The use of the term stress-strain diagram is frequently extended to cover diagrams plotted with values of applied load, or applied moment as ordinates, and with values of stretch, compression, deflection, or twist as abscissas.

Fig. 1 is an example of a stress-strain diagram.

Stress-strain diagrams are in some cases drawn directly by an autographic attachment to the testing machine. A more usual method of procedure consists in taking a series of load readings (from the balanced scale beam of the testing machine) with corresponding readings of the strain-indicating apparatus (extensometer, compressometer, deflectometer, or torsion indicator). The term "strainometer reading" will be used to denote the reading of any strain-measuring instrument. From these readings, or from values computed from them, there is plotted a diagram with stress-indicating values (load, flexural moment, twisting moment, or stress) as ordinates, and strain-indicating values (elongation, shortening, deflection, twist, or strain) as abscissas. In planning such a test it is necessary to decide on the increment of load or the increment of reading of strainometer to be used between successive readings.

In Fig. 2 are shown three typical stress-strain diagrams. The material for all three tests is the same, and the test specimens are all of the same size, so that the diagrams should be the same. The diagram shown in Fig. 2 (*a*) is plotted from points determined by taking increments of load (S). In this diagram it is seen that owing to the shape of the curve, data for locating points between

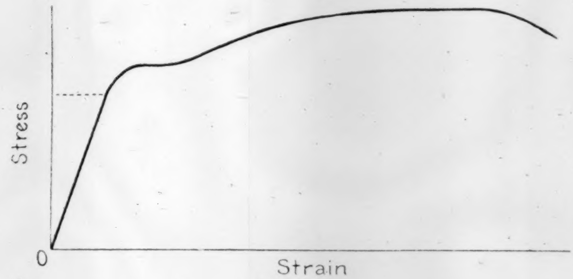
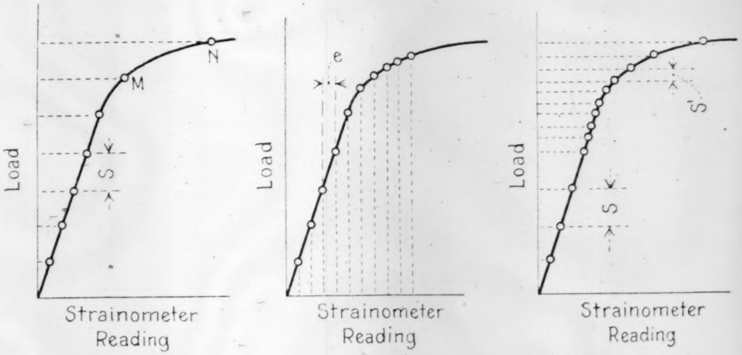


FIG. 1.—A Typical Stress-Strain Diagram.



(*a*) With Equal Increments of Stress.

(*b*) With Equal Increments of Strain.

(*c*) With Two Values of Increments of Stress.

FIG. 2.—Illustrating Three Methods of Plotting Load-Deformation Curves.

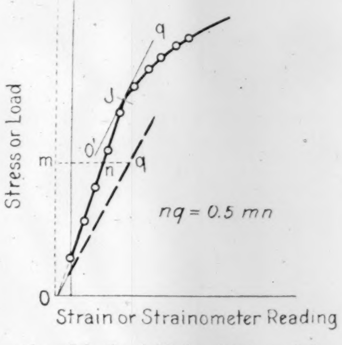


FIG. 3.—Illustrating Method II for Determining Elastic Limit

M and *N* are lacking. That particular portion of the curve (the "knee" of the curve) is the part for which it is especially desirable to locate several points on the diagram.

In Fig. 2 (*b*) is shown a diagram plotted from points determined by taking increments of strainometer reading (*e*). It will be noted that for this diagram there are located several points near the knee of the curve, and the shape of the diagram in this important region is much more definitely determined than for the curve shown in Fig. 2 (*a*).

The custom of choosing increments of load rather than increments of strainometer reading is quite common in tests of materials and is followed because, in general, it is easier to compute increments of load than it is to compute increments of strainometer reading. An estimate of the load necessary to stress the specimen up to the knee of the curve is made and some fraction (frequently one-tenth) of this value is taken as an increment. The computation of the corresponding increment of strainometer reading is more complicated.

Sometimes the practice is followed of applying a few increments of load as determined above, and then applying load in much smaller increments (*S'*) until the knee of the curve is passed. Fig. 2 (*c*) shows a diagram obtained in this manner. This method involves a marked increase in the number of readings necessary for a test and with unknown material there is always some danger that the knee of the curve will be reached before the use of small increments of load is begun.

The following method of choosing increments for a test is suggested: Estimate the load corresponding to the knee of the stress-strain diagram and choose a value for increment of load about one-tenth of this value. Apply this increment of load (*S*) once and note the corresponding change of reading for the strainometer (*e*). Then for the remainder of the test, use for the increment of strainometer reading a value which corresponds to some convenient interval on the scale of the strainometer, and which is approximately equal to (*e*).

Elastic Limit.—The greatest stress which a material can withstand without deformation which remains upon release of the load.

NOTE.—Since experience does not indicate any appreciable difference between the elastic limit and the limit of proportionality of stress to strain (sometimes called the proportional limit), the determination of the stress at the limit of proportionality of stress to strain is regarded as an accurate determination of the elastic limit.

It is obvious that the values obtained in tests for determining the elastic limit will depend on the delicacy of methods and instruments used. It becomes necessary, therefore, that in any test the method used in obtaining the elastic limit be clearly stated. The following methods are in common use for determining a value designated as the elastic limit:

Method I. (For tension tests only, proposed by Committee A-1 on Steel, and embodied in a number of specifications for steel.) The elastic limit shall be determined by an extensometer reading to 0.0002 in. The extensometer shall be attached to the specimen at the gage marks and not to the shoulders of the specimen nor to any part of the testing machine. When the specimen is in place and the extensometer attached, the testing machine shall be operated so as to increase the load on the specimen at a uniform rate. The observer shall watch the elongation of the specimen as shown by the extensometer and shall note, for this determination, the load at which the rate of elongation shows a sudden increase. The extensometer may then be removed from the specimen and the test continued to determine the tensile strength.

Method II (proposed by the late J. B. Johnson) is a somewhat more delicate method for locating the elastic limit than is Method I. In Method II, the elastic limit shall be taken as that stress at which the rate of deformation is 50 per cent greater than the initial rate of deformation. A stress-strain diagram is necessary for determining the elastic limit by Method II. Fig. 3 illustrates the use of Method II. The initial rate of deformation is given by the ratio $mn : Om$. $nq = 0.5\ mn$, $mq = 1.5\ mn$, and the slope of Oq represents a rate of deformation 50 per cent greater than the initial rate. $O'q'$ is drawn parallel to Oq and tangent to the stress-strain diagram. The point of tangency J locates the elastic limit. In using Method II the same precautions should be observed in attaching the strainometer as for the determination of the elastic limit by Method I. Method II, if used for tension tests of metals, gives lower values for the elastic limit than does Method I. It is recommended that in using Method II for tension tests the strainometer be of such sensitiveness that it will indicate a change of unit strain of 0.0001 in. per inch of gage length (0.0001 mm. per millimeter of gage length) and that a corresponding degree of sensitiveness be required for strainometers used for compression tests, for flexure tests, and for torsion tests.

When it is desired to determine the elastic limit with a high degree of precision, it is suggested that the experimenter devise his own procedure, and in reporting his results describe the procedure in detail, including a statement of the limits of sensitiveness of the apparatus used and of the procedure used in plotting the stress-strain diagram from which the determination of elastic limit is made. It is to be remembered that the accurate determination of the elastic limit requires the use of accurate and sensitive instruments and the use of accurate methods of plotting test data.

Yield Point.—The stress in a material at which there occurs a marked increase in strain without an increase in stress.

NOTE.—Some metals do not show a clearly defined yield point.

Two methods are in use for determining the yield point: (I) The "drop of the beam" method, and (II) the method by use of dividers. In Method I, load is applied to the specimen at a steady rate of increase and the operator keeps the beam in balance by running out the poise at a steady rate. At the yield point the increase of load stops, but the operator, running out the poise at a steady rate, runs it a trifle beyond the balance position, and the beam of the machine drops for a brief but appreciable interval of time. In a machine fitted with a self-indicating load-measuring device there is a sudden halt of the load-indicating pointer, corresponding to the drop of the beam. The load at the "halt" or the "drop" is recorded, and the corresponding stress is taken as the yield point. This method of determining the yield point requires only one man to conduct a test.

In Method II for determining the yield point, one observer keeps the beam of the testing machine balanced, and another observer with a pair of dividers watches for visible elongation between two gage marks on the specimen. When visible stretch is observed the fact is at once reported to the man operating the beam of the testing machine, the load at that instant is noted, and the stress corresponding to the load is taken as the yield point. When a strainometer[1] is used in place of dividers a deformation of 0.01 in. over a gage length of 2 in. shall be regarded as indicating the yield point.

Tensile Strength or *Ultimate Tensile Strength.*—The maximum stress carried by a test specimen in a tension test to rupture.

Modulus of Elasticity.—The ratio, within the elastic limit of a material, of stress to corresponding strain.

NOTE.—As there are three kinds of stress, so are there three moduli of elasticity for any material: the modulus in tension, the modulus in compression, and the modulus in shear. The value of the modulus of elasticity in tension is nearly the same, for most metals, as the value of the modulus of elasticity in compression. The value of the modulus of elasticity in shear is smaller than the value of the modulus of elasticity in tension. The modulus of elasticity is expressed in pounds per square inch (kilograms per square millimeter).

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[1] The determination of yield point with a strainometer is sometimes made in tests on non-ferrous metals.

TENTATIVE DEFINITIONS OF TERMS RELATING TO METALLOGRAPHY[1]

Serial Designation: E 2 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1921; REVISED, 1923

Alloy.—A union, possessing metallic properties, of two or more metallic elements, or of metallic and non-metallic elements, which are miscible with each other, at least to some extent when molten, to form a homogeneous liquid and do not separate into distinct layers when solid.

NOTE.—Such combinations when cold may consist of mechanical mixtures, eutectics or eutectoids, solid solutions, or chemical compounds, more than one of which may exist at the same time.

Alpha Brass.—A copper-zinc alloy with a copper content greater than approximately 64 per cent. It is composed of but one type of crystals all of which are of the same composition.

Beta Brass.—A copper-zinc alloy with a copper content of approximately 54 per cent composed of but one type of crystals all of which are of the same composition.

NOTE.—At ordinary temperatures, the normal range of beta brass is from 51 to 55 per cent copper. Quenching from higher temperatures considerably broadens this range. Between 64 per cent copper and 55 per cent copper, the copper-zinc alloys consist of mixed crystals of alpha and beta, the relative proportion of which depends upon the composition and heat treatment. When rapidly cooled from high temperatures (that is, from at or near the melting point) mixed alpha and beta may occur with copper as high as 70 per cent.

Etching Reagent.—A substance or reagent used to reveal the structure of a metal or alloy causing a difference in the appearance of different constituent parts or different grains.

NOTE.—This substance is usually a solution of the reagent in water, acid or alkali, but etching may in some cases be brought out by a differential oxidation produced by "heat tinting."

Equi-axed.—This term is applied to the grains of a metal or alloy after solidification and to grains of metals or alloys which have been strained and allowed by a process of suitable annealing to assume a condition approaching crystallin equilibrium.

Equi-axed Grain.—An unstrained grain which has approximately equal dimensions in all directions.

NOTE.—This term is practically restricted to unstrained metals.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.

These definitions of terms, when adopted as standard, will become a part of the present Standard Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (Serial Designation : E 2 - 20), 1921 Book of A.S.T.M. Standards.

Grain.—A term used for an allotrimorphic crystal present in metals and in one-constituent alloys.

NOTE.—Although a crystal may show division by "twinning," etc., it is regarded as the grain rather than smaller sub-divisions. In the case of alloys of more than one constituent, the crystal which, by its transformation, gave rise to these constituents is taken as the grain when its limits are still discernible; if the limits are not discernible the individual constituents are considered as grains.

Grain Size.—This is preferably expressed as the number of grains per unit area of cross-section. The average cross-sectional area of the grain may also be given or the average dimensions. Grain size of strained material is expressed by the average number per linear unit in two directions, or by the average number per unit cross-sectional area, together with the ratio of length to breadth (L/B).

NOTE.—By the "Intercept" Method for grain count, the number of grains and fractions of grains along a line of known length on two axes at right angles to each other are counted. By the "Planimetric" Method for grain count, the number of grains and fractions of grains within a definite area are counted.

Intercept Method for Grain Count.—See note under Grain Size.

Macrograph.—A graphic reproduction of any object which has been magnified not more than 10 times.

NOTE.—When it is desired to indicate that it is a photographic reproduction, the term "photomacrograph" may be employed.

Magnification.—The ratio of the size of the image to that of the object, based on linear dimensions, and generally expressed in "diameters," thus: ×100 or 100 diameters.

Metal.—Any of the metallic elements, either of very high purity or of ordinary commercial grades.

NOTE.—Brass or other alloy is a metal in the commercial sense, but an alloy in the scientific sense.

Micrograph.—A graphic reproduction of any object magnified more than 10 times.

NOTE.—When it is desired to indicate that it is a photographic reproduction, the term "photomicrograph" may be employed.

Muntz Metal.—A term often loosely applied to a brass, *i. e.*, a copper-zinc alloy, that can be mechanically worked while hot. Originally applied to brass of the composition: copper, 60 per cent; zinc, 40 per cent; such brasses consist of a mixture of two constituents termed "alpha" and "beta."

Planimetric Method for Grain Count.—See note under Grain Size.

TENTATIVE RECOMMENDED PRACTICE

FOR

PHOTOGRAPHY AS APPLIED TO METALLOGRAPHY[1]

Serial Designation: E 7 - 23 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to revision.

ISSUED, 1923

1. The subject of photography as applied in metallography can be conveniently divided into the following sections:

I. Magnifications;
II. Lenses;
III. Illumination of Specimens;
IV. Photographic Materials;
V. Metal Radiography.

I. MAGNIFICATIONS

2. In addition to the magnifications specified in Section 1 of the Standard Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (Serial Designation: E 2) of the American Society for Testing Materials,[2] a magnification of 5 for use in the preparation of macrographs is recommended.

II. LENSES

3. In Table I have been grouped the various lenses and combination of lenses, which will be found convenient for obtaining different magnifications.

III. ILLUMINATION OF SPECIMENS

4. For use with objectives of 32-mm. focal length or less, all of which are used in combination with oculars, vertical illumination (*i. e.*, normal to the surface under observation) is usually necessary. Either the plane-glass or mirror type of illuminator (the latter including the totally reflecting prism) in which the reflector is placed behind the objective may be used. For best results, the condition of "critical

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[1] Criticisms of this Tentative Recommended Practice are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.

[2] 1921 Book of A.S.T.M. Standards.

illumination," that is the optical distance from the source of light (real or apparent) to the surface of the specimen equals the distance from the specimen to the focal plane of the ocular, or, in other words, the source of light should be approximately imaged on the sample. The mirror type of illuminator is not suitable for very short focus objectives (4 mm. or less), since it obscures a relatively large portion of the lens surface.

5. With objectives of the photographic type, vertical illumination is obtained by inserting the illuminator (plane glass) between the lens and the surface of the specimen. Oblique illumination may be obtained by directing the beam of light so that it strikes the surface of the specimen obliquely or, in a lesser degree, by rotating the reflector of the vertical illuminator.

TABLE I.—LENSES FOR VARIOUS MAGNIFICATIONS

Linear Magnification	Objective		Ocular	
	Type	Focal length (approximate), mm.	Type[1]	Remarks
10 or below	Photographic	72	none	
10 to 20	Photographic	48	none	
20 to 30	Photographic	35	none	
30 to 75	Achromatic	32	Huyghens or similar	
75 to 150	Achromatic	16	Huyghens or similar	
200	Achromatic or apochromatic	8		Compensated and "Projection" for apochromatic objectives.
200 to 500	Apochromatic preferred	8		Compensated for large fields.
		4		Compensated for maximum resolution of fine structure.
1000	Apochromatic	4		Compensated for large fields.
		2		Compensated for maximum resolution of fine structures.

[1] The magnifying power of the ocular should be such that the desired size of projected image can be obtained with a moderate length of bellows.

6. For lenses of the photographic type of more than 48-mm. focal length, the illumination is either diffused: for example, daylight; oblique, as obtained by a beam of light directed upon the specimen obliquely from one side; or "vertical." For the last, a large "vertical illuminator" (plane glass) between the lens and object is used. In order to increase the size of the field, which otherwise would be restricted in diameter to that of the photographic lens, a relatively large plano-convex lens should be placed between the reflecting plane-glass and the source of parallel light, the lens being located so that the *optical* distance between it and the photographic lens equals the focal length of the plano-convex lens. Moistening the surface of the specimen with water, glycerin or oil will sometimes be found to be desirable for the purpose of increasing the contrast in the photograph.

7. *Illumination of Fractured Specimens.*—A good reproduction of a fractured specimen may be readily obtained by using two sourcee of artificial light of unequal intensities, placed one on each side of ths specimen. A reflector may be used to replace the weaker light source if desired. The second, or weaker illuminant serves to neutralize partially the deep shadows cast by the stronger one and so produces a good relief effect.

8. *Filters for Microscopy.*—Light filters may be used for any of the following purposes:

(*a*) For obtaining monochromatic (at least approximate) light. This is particularly desirable for achromatic lenses. Filters having a dominant wave length of 5500 Å. U. (*i. e.*, yellowish green) are very suitable for *general* use with such lenses, since most achromatic lenses being designated for visual rather than photographic purposes, are corrected for this portion of the spectrum.

(*b*) For increasing the contrast between various constituents—the color of the filter must, of course, be chosen according to the object to be examined.

(*c*) For lengthening the time of exposure in case of very brilliant illumination, thus avoiding the use of very small diaphragm openings.

(*d*) For taking advantage of the maximum resolving power of a lens, for example, in very high magnification, for which violet or blue filters are recommended.

IV. PHOTOGRAPHIC MATERIALS

9. *Plates.*—A medium-speed, that is, moderately fine-grained, photographic plate will be found very suitable for most photomicrographic work for showing details of structure.

If color sensitivity must be taken into account, a panchromatic (*i. e.*, sensitized for all colors) plate may be necessary, though for most metallographic specimens one of the orthochromatic type (sensitive to yellow green in addition to the blue end of the spectrum) will usually be found to answer the purpose. For some purposes, "contrast" plates are desirable; this may be the case when there are but few structural details, for example, inclusions in a polished but unetched metallic matrix or for some low-magnification examinations.

10. *Paper.*—As a general rule, a printing paper with a glossy surface is desirable. The maximum gloss can be obtained by drying the prints on enameled or "ferro type" plates which have been previously brushed with a solution of paraffin wax in benzol or other solvent and then polished.

V. METAL RADIOGRAPHY

11. The use of X-rays for the study of metals is for one of two purposes:

(*a*) The determination of the crystallin or "atomic" structure. This method is used as yet for research purposes only.

(*b*) The determination of the physical homogeneity of the interior of metals without cutting the material in any way. On account of the limited application of this method for metallurgical purposes, reference will only be made to available published information on this subject.[1]

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[1] W. E. Ryder, "Metal Radiography," *Year Book*, American Iron and Steel Inst., p. 352, (1919); Symposium, "The Examination of Materials by X-rays." *Journal*, Faraday Society, 1919; H. H. Lester, "Radiography of Metals," *Army Ordnance*. Washington, D. C., January, 1923, Vol. III, No. 16, p. 210.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative Revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

A. FERROUS METALS

STANDARD SPECIFICATIONS FOR OPEN-HEARTH STEEL GIRDER AND HIGH TEE RAILS

(SERIAL DESIGNATION: A 2 - 21)[1]

Section 7 (b).—Change to read as follows by the addition of the italicized words:

"Excess scale on the head *or web* of the section shall be carefully removed."

Section 8.—Change from its present form: namely,

"(*a*) The head of each specimen shall be subjected to a pressure of 50 net tons (100,000 lb.) for a period of 15 seconds, applied through a ball ¾ in. in diameter.

"(*b*) The average depth of impression obtained on the four specimens shall not be more than 3.8 mm. for Class A rails, nor more than 3.6 mm. for Class B rails."

to read as follows:

"(*a*) *Impression Test.*—The head of each specimen shall be subjected to a pressure of 100,000 lb. (45,359 kg.) net for a period of 15 seconds applied through a hardened steel ball 0.75 in. (19.05 mm.) in diameter.

"(*b*) *Test Balls.*—The steel test ball shall have a minimum Brinell hardness of 600 and it shall not be possible to attack the surface of the ball with an American Swiss Pillar File No. 2.

"(*c*) *Permissible Variation in Test Balls.*—When fractured, the ball shall show a fine uniform grain, with no indications of overheat or underheat and the fracture shall resist file attack for at least one-third of its depth from the surface of the ball. The permissible variation in the diameter of the ball shall not be greater than 0.002 in. over or under the standard size, and the permanent deformation under the required loading shall not be over 0.003 in.

"(*d*) *Depths of Impressions.*—The average depth of impression obtained on the four specimens shall not be more than 0.1496 in. (3.8 mm.) for Class A rails, nor more than 0.1471 in. (3.6 mm.) for Class B rails."

Section 9.—Change the reference from Section 8 (*b*) to Section 8 (*d*).

Section 12 (a).—Change the reference from Section 11 to Section 10.

Section 15.—Change from its present form: namely,

"The ends shall be milled square laterally and vertically, but the base may be undercut $\frac{1}{32}$ in."

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

to read as follows:

"The ends shall be milled square laterally. They shall be undercut vertically not less than $\frac{1}{32}$ in. and not over $\frac{3}{32}$ in."

Section 18 (a).—Change the reference from Section 11 to Section 10.

STANDARD SPECIFICATIONS FOR STEEL TRACK SPIKES

(SERIAL DESIGNATION: A 65 - 18)[1]

Section 6.—Change to read as follows:

"The spikes shall conform to the dimensions specified by the purchaser except that a variation of $\frac{1}{32}$ in. over and $\frac{1}{64}$ in. under the specified dimension of the body of the spike, and a variation of $\frac{1}{8}$ in. over and $\frac{1}{16}$ in. under the specified dimension of the head of the spike will be permitted. A variation of $\frac{1}{4}$ in. over and nothing under the specified length of the spike, measured from the under side of the head to the point, will be permitted. A variation of 1 deg. in the specified angle of the under side of the head of the spike will be permitted."

STANDARD SPECIFICATIONS FOR STRUCTURAL NICKEL STEEL

(SERIAL DESIGNATION: A 8 - 21)[1]

Section 6 (a).—In the table on tensile requirements, insert the requirement of 18 per cent for the minimum elongation in 2 in. for shapes, plates, and bars.

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR LOCOMOTIVES

(SERIAL DESIGNATION: A 10 - 21)[1]

Section 6 (a).—Insert the following requirement:

"Elongation in 2 in., min., per cent.......................... 22"

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR CARS

(SERIAL DESIGNATION: A 11 - 21)[1]

Section 6 (a).—In the table on tensile requirements, insert the requirement of 22 per cent for the minimum elongation in 2 in. for structural steel.

STANDARD SPECIFICATIONS FOR STEEL CASTINGS

(SERIAL DESIGNATION: A 27 - 21)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Steel Castings (A 27 - 23 T)"[2] is intended to replace the present standard specifications.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

[2] See p. 555.

STANDARD SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL BOILER TUBES FOR LOCOMOTIVES

(SERIAL DESIGNATION: A 28 - 21)[1]

Section 14 (c).—Divide this section into two separate paragraphs (*c*) and (*d*) as follows, relettering Paragraph (*d*) to Paragraph (*e*):

"(*c*) The thickness of hot-finished tubes at any point shall not exceed two gages above or one gage below that specified, but in all cases the weight variation shall be within that specified in Paragraph 13 (*b*).

"(*d*) In the case of boiler tubes that are expanded and swaged, the thickness of the expanded end may be 1½ gages lighter and the swaged end three gages heavier than the thickness specified."

STANDARD SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE

(SERIAL DESIGNATION: A 53 - 21)[1]

Section 3.—Change to read as follows by the addition of the italicized words and figures:

"Open-hearth steel shall conform to the following requirements as to chemical composition:

	Lap-Welded	*Seamless*
Phosphorus, per cent..................	*not over 0.06*	not over 0.05"

Tables I and II.—Omit the words "Black and Galvanized" now appearing under the titles of these tables.

STANDARD SPECIFICATIONS FOR AUTOMOBILE CARBON AND ALLOY STEELS

(SERIAL DESIGNATION: A 29 - 21)[1]

Table I.—Add to the present table the five following compositions:

Carbon		Manganese.		Phosphorus.	Sulfur.
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.045	0.05
0.30	0.25 - 0.35	0.65	0.50 - 0.80	"	"
0.40	0.35 - 0.45	0.65	0.50 - 0.80	"	"
0.46	0.40 - 0.50	0.40	0.30 - 0.50	"	"
0.50	0.45 - 0.55	0.65	0.50 - 0.80	"	"

Table II.—In the steel of 0.15 per cent carbon, change the manganese requirement from 0.65 per cent desired (permissible range 0.50–0.80 per cent) to 0.45 per cent desired (permissible range 0.30–0.60 per cent).

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

Add to the present table the following composition:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.
0.50	0.45 - 0.55	0.65	0.50 - 0.80	0.04	0.045	3.50	3.25 - 3.75

Table III. (*With 1.25 per cent Nickel*).—In the steel of 0.20 per cent carbon, change the manganese from 0.65 per cent desired (permissible range 0.50 - 0.80 per cent) to 0.45 per cent desired (permissible range 0.30 - 0.60 per cent).

Add to the present table the following composition:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.	Desired.	Permissible Range.
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.04	0.04	1.25	1.00 - 1.50	0.60	0.45 - 0.75

Table III. (*With 1.75 per cent Nickel*).—Add to the present table, the two following compositions:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.	Desired.	Permissible Range.
0.15	0.10 - 0.20	0.45	0.30 - 0.60	0.04	0.04	1.75	1.50 - 2.00	1.10	0.90 - 1.25
0.45	0.40 - 0.50	0.45	0.30 - 0.60	0.04	0.04	1.75	1.50 - 2.00	1.10	0.90 - 1.25

Table III. (*With 3.50 per cent Nickel*).—Omit the compositions appearing under the heading "With 3.50 per cent Nickel" and insert the following compositions:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Nickel.		Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.	Desired.	Permissible Range.
0.12	Max., 0.17	0.45	0.30 - 0.60	0.04	0.04	3.50	3.25 - 3.75	1.50	1.25 - 1.75
0.25	0.20 - 0.30	"	"	"	"	"	"	"	"
0.35	0.30 - 0.40	"	"	"	"	"	"	"	"
0.40	0.35 - 0.45	"	"	"	"	"	"	"	"

Table IV.—Omit the present compositions and insert the following:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Chromium.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired	Permissible Range.
0.20	0.15 - 0.25	0.45	0.30 - 0.60	0.04	0.045	0.75	0.60 - 0.90
0.40	0.35 - 0.45	0.65	0.50 - 0.80	0.04	0.045	0.95	0.80 - 1.10
0.50	0.45 - 0.55	0.65	0.50 - 0.80	0.04	0.045	0.95	0.80 - 1.10
1.00	0.95 - 1.10	0.35	0.20 - 0.50	0.03	0.030	1.35	1.20 - 1.50

Omit the present footnote (*a*) as appearing under Table IV.

Table VII.—Omit the present compositions and insert the following:

Carbon.		Manganese.		Phosphorus.	Sulfur.	Silicon.	
Desired.	Permissible Range.	Desired.	Permissible Range.	Not Over	Not Over	Desired.	Permissible Range.
0.50	0.45 - 0.55	0.75	0.60 - 0.90	0.045[a]	0.045	2.00	1.80 - 2.20
0.60	0.55 - 0.65	"	"	"	"	"	"

[a] Steels made by the acid process may contain 0.05 maximum phosphorus.

STANDARD SPECIFICATIONS FOR BOILER AND FIREBOX STEEL FOR LOCOMOTIVES

(SERIAL DESIGNATION: A 30 - 21)[1]

Section 3.—In the table on chemical requirements, change the requirements for carbon to read as follows by the addition of the italicized words, and the omission of the figures in brackets:

		FIREBOX
Carbon	for plates $\frac{3}{4}$ in. or under in thickness....	[0.12-] *not over* 0.25 per cent
	for plates over $\frac{3}{4}$ in. in thickness........	[0.12-] *not over* 0.30 per cent

Section 6 (a).—In the table on tensile requirements, change the requirement for minimum elongation in 8 in. for firebox steel from $\frac{1\ 500\ 000}{\text{Tens. str.}}$ to $\frac{1\ 550\ 000}{\text{Tens. str.}}$

Section 14 (a).—Change from its present form: namely,

> "(*a*) The name or brand of the manufacturer, melt or slab number, class and lowest tensile strength for its class specified in Section 6 (*a*), shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen."

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

to read as follows:

"The name or brand of the manufacturer, the manufacturer's test identification number, class and lowest tensile strength specified shall be legibly stamped on each finished plate in two places not less than 12 in. from the edges and on each butt strap near the center line not less than 12 in. from each end. The manufacturer's test identification number shall be legibly stamped on each test specimen."

STANDARD SPECIFICATIONS FOR BOILER RIVET STEEL

(SERIAL DESIGNATION: A 31 - 21)[1]

Section 9.—Change from its present form: namely,

"The diameter of each bar shall not vary more than 0.01 in. from that specified."

to read as follows:

"The diameter of hot-finished rivet bars shall not vary from that specified by more than the amount given in the following table:

Diameters, in.	Variations in Diameter, in. Under	Over	Out of Round, in.
Up to $\frac{1}{2}$, inclusive	0.007	0.007	0.010
Over $\frac{1}{2}$ to 1, inclusive	0.010	0.010	0.013
Over 1 to $1\frac{1}{4}$, inclusive	0.012	0.012	0.016
Over $1\frac{1}{4}$ to $1\frac{1}{2}$, inclusive	0.015	0.015	0.021
Over $1\frac{1}{2}$ to 2, inclusive	0.022	0.022	0.023

Section 10.—Omit this section, reading as follows, re-numbering the subsequent sections accordingly:

"The finished bars shall be circular within 0.01 in."

Section 16.—Omit this section, reading as follows, re-numbering the subsequent sections accordingly:

"The rivets, when tested, shall conform to the requirements as to tensile properties specified in Section 5, except that the elongation shall be measured on a gage length not less than four times the diameter of the rivet."

Section 19 (a).—Omit this paragraph, reading as follows:

"*(a)* When specified, one tension test shall be made from each size in each lot of rivets offered for inspection."

Section 20.—Change from its present form: namely,

"The rivets shall be true to form, concentric, and shall be made in a workmanlike manner."

to read as follows:

"The rivets shall be true to form and concentric, shall be made in a workmanlike manner, and shall be free from injurious defects."

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

Section 21.—Omit this section, reading as follows, re-numbering the subsequent sections accordingly:

"The finished rivets shall be free from injurious defects."

STANDARD SPECIFICATIONS FOR WELDED WROUGHT-IRON PIPE

(Serial Designation: A 72 - 21)[1]

Section 3 (a).—Change the words "puddled pig iron" to read "all pig puddled iron."

Omit the words "Black and Galvanized" from under the titles of Tables I and II.

STANDARD SPECIFICATIONS FOR WROUGHT-IRON ROLLED OR FORGED BLOOMS AND FORGINGS FOR LOCOMOTIVES AND CARS

(Serial Designation: A 73 - 18)[1]

Section 6 (a).—Change the requirements given in the table included in Section 6 (*a*) from their present form: namely,

Tensile strength, lb. per sq. in.	45 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 4 in., per cent	22
Reduction of area, per cent	30

to read as follows:

	Blooms	Forgings, Classes A and B
Tensile strength, lb. per sq. in.	45 000	45 000
Yield point, lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 4 in., per cent	22	24
Reduction of area, per cent	30	33

STANDARD SPECIFICATIONS FOR FOUNDRY PIG IRON

(Serial Designation: A 43 - 09)[2]

A revision in the form of separate tentative specifications entitled "Specifications for Foundry Pig Iron (A 43 - 22 T)"[3] is intended to replace the present standard specifications.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. B. Young, Secretary of Committee A-2 on Wrought Iron, Philadelphia and Reading Railway Co., Reading, Pa.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. C. Davies, Secretary of Committee A-3 on Cast Iron, 1410 Real Estate Trust Building, Philadelphia, Pa.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 566 (1922).

STANDARD SPECIFICATIONS FOR MALLEABLE CASTINGS

(SERIAL DESIGNATION: A 47 – 19)[1]

Section 3.—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

"The tension test specimens specified in Section 5 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	[45 000]	*50 000*
Elongation in 2 in., per cent.....................	[7.5]	*10.0*"

Section 6 (b).—Add a sentence to read as follows:

"In case one of the retest specimens contains a flaw which results in the failure of the bar to meet the specifications, at the discretion of the inspector additional test specimens from the same oven may be tested, or test specimens may be cut from castings."

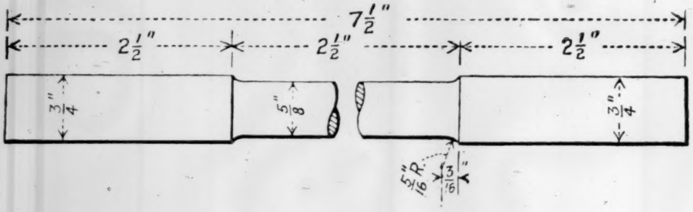

FIG. 1.

It is further recommended that the standard test specimen be modified to conform to the dimensions shown in Fig. 1. As may be noted, this changes the total length of the test specimen from 12 in. to 7½ in. and gage length from 4 in. to 2 in.

STANDARD METHODS OF TEST FOR MAGNETIC PROPERTIES OF IRON AND STEEL

(SERIAL DESIGNATION: A 34 – 18)[2]

A revision in the form of separate tentative methods entitled "Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 23 T)"[3] is intended to replace the present standard methods.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Enrique Touceda, Secretary of Committee A-7 on Malleable Castings, Broadway, Corner Thatcher St., Albany, N. Y.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

[3] See p. 560.

STANDARD METHODS OF CHEMICAL ANALYSIS OF PLAIN CARBON STEEL

(SERIAL DESIGNATION: A 33 - 14)[1]

A revision in the form of separate methods of chemical analysis, entitled "Methods of Chemical Analysis of Plain Carbon Steel (A 33 - 22 T)"[2] is intended to replace the present standard methods.

STANDARD METHODS OF CHEMICAL ANALYSIS OF ALLOY STEELS

(SERIAL DESIGNATION: A 55 - 15)[1]

A revision in the form of separate methods of chemical analysis, entitled "Methods of Chemical Analysis of Alloy Steels (A 55 - 22 T)[3] is intended to replace the present standard methods.

RECOMMENDED PRACTICE FOR ANNEALING OF CARBON-STEEL CASTINGS

(SERIAL DESIGNATION: A 36 - 14.)[4]

A revision in the form of a separate recommended practice entitled "Recommended Practice for Heat Treatment of Carbon-Steel Castings (A 36 - 22 T)"[5] is intended to replace the present recommended practice.

B. NON-FERROUS METALS

STANDARD METHODS OF CHEMICAL ANALYSIS OF PIG LEAD

(SERIAL DESIGNATION: B 35 - 20)[6]

A revision in the form of a separate tentative method entitled "Method for Determination of Zinc in Pig Lead (B 35 - 23 T)"[7] is intended to replace the present Method for Determination of Zinc and the Method for Determination of Manganese in the present standard methods.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Parkesburg Iron Co., Parkesburg, Pa.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 578 (1922).

[3] *Ibid*, p. 600.

[4] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. H. Hall, Secretary of Committee A-4 on Heat Treatment of Iron and Steel, Taylor-Wharton Iron and Steel Co., High Bridge, N. J.

[5] *Proceedings*, Am. Soc. Testings Mats., Vol. 22, Part I, p. 643 (1922).

[6] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

[7] See p. 594.

C. CEMENT, LIME, GYPSUM AND CLAY PRODUCTS

STANDARD SPECIFICATIONS AND TESTS FOR PORTLAND CEMENT

(SERIAL DESIGNATION: C 9 – 21)[1]

A revision in the form of a separate tentative specification entitled "Specifications and Tests for Compressive Strength of Portland Cement Mortars (C 9 – 16 T)"[2] is intended to become a part of the present standard specifications.

STANDARD SPECIFICATIONS FOR DRAIN TILE

(SERIAL DESIGNATION: C 4 – 21)[3]

Section 15.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The purchaser shall choose (1) sand bearings, (2) [hydraulic] *two-edge* bearings, or (3) [three-point] *three-edge* bearings for use in making strength tests of drain tile. (See Sections 18, 19, and 20.)"

Section 16.—Change the second paragraph to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The ordinary supporting strength shall be calculated by multiplying the test breaking loads by the following factors: For sand bearings, 1.00; for [hydraulic] *two-edge* bearings, [1.25] *1.50*; for [three-point] *three-edge* bearings, 1.50."

Section 17.—Change the first sentence of the second paragraph to read as follows by the addition of the italicized words and the omission of the words in brackets:

"Five-eighths of the weight of the tile per linear foot for sand bearings, or three-fourths for [hydraulic or three-point] *two-edge or three-edge* bearings, shall be added to W in computing the maximum bending moment M, when such addition exceeds 5 per cent of W."

Section 19.—Change from its present form: namely,

"19. (See Fig. 2.)—When hydraulic bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.

"An hydraulic bearing shall be composed of a wooden platen, to which is attached, as hereinafter described, a section of rubber hose. The hose shall lie against the tile, and the pressure shall be applied to the hose through the platen.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. B. Young, Secretary of Committee C-1 on Cement, Hydro-Electric Power Commission of Ontario, 8 Strachan Ave., Toronto, Ontario, Canada.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920).

[3] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. W. Pickels, Secretary of Committee C-6 on Drain Tile, University of Illinois, Urbana, Ill.

"The platen shall be built of strong wood, and shall be not less than 6 by 6 in. in section, and its least length shall be the length of the tile plus 8 in. One-inch quarter rounds, with their convex surfaces facing and 2 in. apart in the clear, shall be firmly attached to the bearing side. The straight portion of this face shall extend at least the length of the tile, and the platen beyond this length may be cut to the arc of a circle.

"Between the quarter rounds shall be laid a piece of $2\frac{1}{2}$-in. hose which shall be closed in a water-tight manner at each end by clamps. The hose shall contain a volume of water not less than one-half nor more than two-thirds its capacity, when completely distended. This hose may be attached to the platen at either end in any satisfactory manner which will not induce wrinkling when under test pressure.

"The test load shall be applied at the middle of the top bearing, in such a way as to leave the bearing free to move in the vertical plane of the axis of the tile.

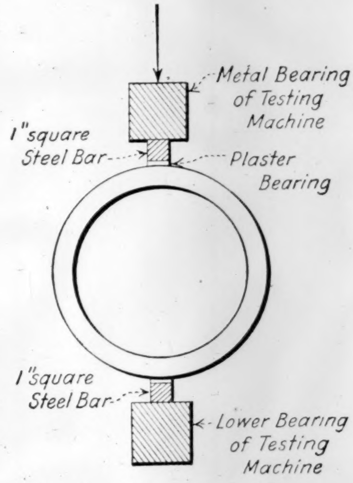
Metal Bearing of Testing Machine
1" square Steel Bar
Plaster Bearing
1" square Steel Bar
Lower Bearing of Testing Machine

FIG. 2.—Two-Edge Bearings

"It is recommended that stops be screwed to the platen, symmetrical with the point of application of the load, and at a distance apart not greater than the length of the tile plus $\frac{1}{2}$ in. This will help center the load coming upon the tile."

to read as follows:

"*Two-edge Bearings.* (See Fig. 2.)—When two-edge bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test.

"The tile to be tested shall be supported by a metallic knife bearing 1 in. wide and extending the length of the tile. Before the tile is placed, a fillet of plaster of Paris and sand 1 in. wide, and thick enough to compensate for all the inequalities of the tile barrel, shall be cast on the surface of the knife-edge bearing. The tile shall be placed upon the fillet while the plaster of Paris is still somewhat plastic. The load shall be applied through an upper knife bearing of the same size and length as the lower bearing. A plaster-of-Paris fillet 1 in. wide shall be cast along the length of the crown of the tile to equalize the lower bearing before the upper one is brought into contact.

"Both of the bearings shall be sufficiently rigid to transmit and receive uniform loads throughout their lengths without deflection, and shall be so attached to the machine as to transmit and receive the maximum stresses produced by the test without lost motion, vibration, or sudden shock."

Section 20.—Change the first sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

"*Three-edge Bearings.* (See Fig. 3.)—When [three-point] *three-edge* bearings are used, the ends of each specimen of tile shall be accurately marked in halves of the circumference prior to the test."

Table I.—Change Table I to appear as follows:

TABLE I.—PHYSICAL TEST REQUIREMENTS FOR DIFFERENT CLASSES OF DRAIN TILE

Internal Diameter of Tile, in.	Farm Drain Tile				Standard Drain Tile				Extra-Quality Drain Tile			
	Minimum Average Ordinary Supporting Strength, lb. per linear ft	Maximum Average Absorption by Standard Boiling Test, per cent			Minimum Average Ordinary Supporting Strength, lb. per linear ft.	Maximum Average Absorption by Standard Boiling Test, per cent			Minimum Average Ordinary Supporting Strength, lb. per linear ft.	Maximum Average Absorption by Standard Boiling Test, per cent		
		Shale and Fire-Clay Tile	Surface-Clay Tile	Concrete Tile		Shale and Fire-Clay Tile	Surface-Clay Tile	Concrete Tile		Shale and Fire-Clay Tile	Surface-Clay Tile	Concrete Tile
4	800	11	14	12	1200	9	13	10	1600	7	11	9
5	800	11	14	12	1200	9	13	10	1600	7	11	9
6	800	11	14	12	1200	9	13	10	1600	7	11	9
8	800	11	14	12	1200	9	13	10	1600	7	11	9
10	800	11	14	12	1200	9	13	10	1600	7	11	9
12	800	11	14	12	1200	9	13	10	1600	7	11	9
15	1000	11	14	12	1300	9	13	10	1600	7	11	9
18	(Not Permitted)	(Not Permitted)	(Not Permitted)	(Not Permitted)	1400	9	13	10	1800	7	11	9
21					1550	9	13	10	2100	7	11	9
24					1700	9	13	10	2400	7	11	9
27					1850	9	13	10	2700	7	11	9
30					2000	9	13	10	3000	7	11	9
33					2150	9	13	10	3300	7	11	9
36					2300	9	13	10	3600	7	11	9
39					2450	9	13	10	3900	7	11	9
42					2600	9	13	10	4200	7	11	9

Fig. 2.—Change Fig. 2 to conform to Fig. 2 above.

Fig. 3.—Change the title of Fig. 3 from "Three-Point Bearings" to read: "Three-Edge Bearings."

STANDARD SPECIFICATIONS FOR PAVING BRICK

(SERIAL DESIGNATION: C 7 - 15)[1]

Include as an appendix to the specifications the following recommendations for sizes of brick:

	WIDTH, IN.	DEPTH, IN.	LENGTH, IN.
Plain wire-cut brick (vertical fiber, lugless)....	3[a]	4[a]	8½
" " " " " "	3½[a]	4[a]	8½
Repressed lug brick........................	3½	4	8½
Wire-cut lug brick (Dunn)..................	3½	3	8½
" " " "	3½	3½	8½
" " " "	3½	4	8½

[a] These bricks are customarily laid in the pavement to give a depth of 3 in. and 3½ in., respectively, by 4 in. in width by 8½ in. in length.

STANDARD SPECIFICATIONS FOR CLAY SEWER PIPE

(SERIAL DESIGNATION: C 13 - 20)[2]

Section 6.—Omit the last sentence: Add to the preceding sentence the words "except that in no case shall the number of specimens furnished be less than five."

Section 7.—Insert after the word "test" in the seventh line, the words "without charge." Omit the words "without charge" in the eighth line and substitute the words "to be selected as specified in Section 6." Add a new paragraph to read as follows:

> "In addition to the foregoing requirements, failure of individual specimens to develop 75 per cent of the average crushing strength requirements shall be cause for rejection of the shipment, but the seller may cull the pipe and submit the balance of the shipment for re-test, and, if the shipment then passes all of the requirements of these specifications, it shall be accepted."

Section 11.—Omit the portion of the last sentence reading as follows:

"and by then multiplying the quotient by the following factors:

For knife or two-edge bearings........................	$\frac{10}{7}$
" three-edge bearings........................	$\frac{10}{7}$
" sand bearings........................	1.00"

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. E. Emley, Secretary of Committee C-3 on Brick, U. S. Bureau of Standards, Washington, D. C.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. F. B. Lysle, Secretary of Committee C-4 on Clay and Cement Sewer Pipe, 900 City Hall, Philadelphia, Pa.

Table II.—Amend Table II to read as follows:

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CLAY SEWER PIPE

Internal Diameter, in.	Average Crushing Strength, lb. per lin. foot.		Maximum Absorption, per cent.
	Knife Edge[1] and Three-Point[2] Bearings.	Sand Bearing.[3]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8
39	3300	4710	8
42	3520	5030	8

[1] See Section 11. [2] See Section 12. [3] See Section 13.

Table III.—In the second column, entitled "Laying Length," add the figures $2\frac{1}{2}$ for sizes 27 in. to 42 in., inclusive.

STANDARD SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE

(SERIAL DESIGNATION: C 14 – 20)[1]

Section 6.—Omit the last sentence. Add to the preceding sentence the words "except that in no case shall the number of specimens furnished be less than five."

Section 7.—Insert after the word "test" in the seventh line, the words "without charge." Omit the words "without charge" in the eighth line and substitute the words "to be selected as specified in Section 6." Add a new paragraph to read as follows:

> "In addition to the foregoing requirements, failure of individual specimens to develop 75 per cent of the average crushing strength requirements shall be cause for rejection of the shipment, but the seller may cull the pipe and submit the balance of the shipment for re-test, and, if the shipment then passes all of the requirements of these specifications, it shall be accepted."

Section 11.—Omit the portion of the last sentence reading as follows:

"and by then multiplying the quotient by the following factors:

For knife or two-edge bearings	$\frac{10}{7}$
" three-edge bearings	$\frac{10}{7}$
" sand bearings	1.00"

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. F. B. Lysle, Secretary of Committee C-4 on Clay and Cement Sewer Pipe, 900 City Hall, Philadelphia, Pa.

Table II.—Amend Table II to read as follows:

TABLE II.—PHYSICAL TEST REQUIREMENTS OF CEMENT-CONCRETE SEWER PIPE

Internal Diameter, in.	Average Crushing Strength, lb. per lin. foot.		Maximum Absorption, per cent.
	Knife Edge[1] and Three-Point[2] Bearings.	Sand Bearing.[3]	
4	1000	1430	8
6	1000	1430	8
8	1000	1430	8
10	1100	1570	8
12	1200	1710	8
15	1370	1960	8
18	1540	2200	8
21	1810	2590	8
24	2150	3070	8
27	2360	3370	8
30	2580	3690	8
33	2750	3930	8
36	3080	4400	8
39	3300	4710	8
42	3520	5030	8

[1] See Section 11. [2] See Section 12. [3] See Section 13.

Table III.—In the second column, entitled "Laying Length," add the figures $2\frac{1}{2}$ for sizes 27 in. to 42 in., inclusive

STANDARD SPECIFICATIONS FOR CALCINED GYPSUM

(SERIAL DESIGNATION: C 23 – 22)[1]

Section 1.—Omit the footnote to this section reading as follows:

"Specifications for the color and plasticity of calcined gypsum will be supplied when the information is available."

STANDARD SPECIFICATIONS FOR FIRE TESTS OF MATERIALS AND CONSTRUCTION

(SERIAL DESIGNATION: C 19 – 18)[2]

Section 2 (a).—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The temperature fixed by the curve shall be deemed to be the average [true] temperature [of the furnace gases as] obtained from the readings of several thermo-couples (not less than three) symmetrically disposed and distributed [in such a manner as] to show [temperatures of the gases] ***the temperature*** near all parts of the sample, ***said thermo-couples being enclosed in sealed porcelain tubes of $\frac{3}{4}$-in. outside diameter and $\frac{1}{8}$-in. wall thickness, the immersion of the couple in the furnace chamber to be not less than 12 in. Other types of pro-***

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[1] A.S.T.M. Standards Adopted in 1922. Criticisms of this revision are solicited and should be directed to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. P. Miller, Secretary of Committee C-5 on Fireproofing, 25 W. Forty-fifth St., New York City.

tecting tubes or pyrometers may be used, that under test conditions give the same indications as the above standard within the limit of accuracy that applies for furnace temperature measurements.

For greater difference of design and size the time temperature curve followed shall be modified to give an exposure equal to that obtained by using the standard pryometer and curve above described.

Section 6.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"The fire test on the sample with its applied load, if any, shall be continued until failure occurs, or until it has withstood the test conditions for a period equal to [1¼ times that for which classification is desired] *that herein specified in the Conditions of Acceptance for the given type of construction.*"

TABLE I

Parts of Structure.	Type of Protection.	Size of Hose Nozzle, in.	Water Pressure at Nozzle, lb.	Time of Application, min.
Floors and Roofs	4 hour	1 1/8	50	[10] *7*
	2 "	1 1/8	50	[5] *4*
	1 "	1 1/8	50	[2.5] *2*
	1/2 "	1 1/8	30	1
	1/4 "	1 1/8	[15] *30*	1
Walls, [Columns] and Partitions	4 "	1 1/8	50	5
	2 "	1 1/8	30	3
	1 "	1 1/8	30	[3.5] *2*
	1/2 "	1 1/8	30	1
	1/4 "	1 1/8	[15] *30*	1
Columns	*4* "	*1 1/8*	*50*	*3*
	2 "	*1 1/8*	*30*	*2*
	1 "	*1 1/8*	*30*	*1 1/2*
	1/2 "	*1 1/8*	*30*	*1*
	1/4 "	*1 1/8*	*30*	*1/2*

Section 7.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"A second test with duplicate sample shall be made to determine the effect of a hose stream on a sample under fire test, the water being applied at the end of a period equal to [three-fourths] *one-half* of that for which classification is desired, but not later than one hour after the beginning of the test; except that for classification periods of one-half hour or less the fire stream test may be omitted.

Table I.—Change Table I, referred to in Section 8, to read as indicated in the accompanying Table I by the addition of the italicized word and figures and the omission of the word and figures in brackets.

Section 9.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets, changing the side heading from "Loading" to "Loading and Additional Tests":

"For any material or construction intended to carry load other than its own weight, the full [rated safe] working load shall be applied during the entire fire test, also during the fire stream test. After completion of the fire stream test, the sample shall be subjected to [excess loading as prescribed under specifications for the different structural parts] *additional tests as herein specified in the Conditions of Acceptance for the given type of construction.*"

Add a new Section 10, under the sub-division "Conduct of Fire Tests," entitled "Time of Testing," to read as follows:

"The material or construction shall not be tested until a large proportion of its final strength has been attained and the excess of free water has been given off. Where this cannot be attained within 40 days, artificial drying with air temperature not exceeding 100° F. shall be used."

Section 10.—Renumber the present Section 10 to Section 12.

Section 11.—Omit this section reading as follows:

"The floor or roof may be tested as soon after construction as desired, but within 40 days. Artificial drying will be allowed if desired."

Section 12.—Transfer this section, placing it under the subdivision "Conduct of Fire Tests," renumbering it Section 11.

Section 14.—Change the side heading to read "Conditions of Acceptance."

Section 14 (a).—Change to read as follows by the omission of the words in brackets:

"The floor or roof shall have sustained safely the full [rated safe] working load during the fire test without passage of flame for a period equal to 1¼ times that for which classification is desired."

Section 18.—Change the side heading to read "Conditions of Acceptance."

Add five new sections relating to column tests to read as follows:

19. *Size of Sample.*—For column tests, the length of the column exposed to fire shall approximate the clear length of the member in the structure, and for building columns shall be not less than 9 ft. The outside lateral dimensions shall be the minimum for which classification is desired. The details of construction, and exposed connections and protection, if any, shall be applied according to the methods of acceptable field practice.

20. *Loading.*—During the fire test and the fire and water test, a constant working load shall be applied to the column, calculated according to the governing design regulations. Provisions shall be made for transmitting the load to the exposed portion without unduly increasing the effective column length.

21. *Measurements.*—Measurements shall be made of the expansion or depression at the head of the column and determination of the period of expansion. Such other measurements shall be made of deformation and of temperature of the column as will give the most useful information for the given column type.

22. *Position of Nozzle.*—The distance of the nozzle from the column during the application of water shall be 20 ft., the water being applied in succession, as uniformly as possible, over the full height on three of its sides.

23. *Conditions of Acceptance.*—The test shall not be regarded as successful unless the following conditions are met:

(*a*) The column shall have sustained the full working load during the fire test for a period equal to —[1] times that for which classification is desired.

(*b*) The column shall have sustained the full working load during the fire stream test as prescribed in Sections 7 and 8, and after its completion and when cold shall sustain a total load equal to the dead load component plus twice the live load component of its design working load.

(*c*) After the fire stream test the column when dry shall withstand, under working load, a fire test of duration equal to —[1] of the period for which classification is desired, but not exceeding one hour.

D. MISCELLANEOUS MATERIALS

STANDARD SPECIFICATIONS FOR PURITY OF RAW TUNG OIL

(SERIAL DESIGNATION: D 12 – **16**)[2]

A revision in the form of separate specifications entitled "Specifications for Raw Tung Oil (D 12 – 23 T)[3] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR MATERIALS FOR CEMENT MORTAR BED FOR BRICK, STONE BLOCK AND WOOD BLOCK PAVEMENTS

(SERIAL DESIGNATION: D 58 – 20)[4]

1. *Title.*—Change to read as follows by the addition of the italicized words and the omission of the word in brackets:

"Standard Specifications for Materials for Cement Mortar Bed for Brick, Stone Block, [and] Wood Block, *Asphalt Block and Other Block* Pavements."

2. *Section 2.*—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"(*a*) The sand shall be well graded from coarse to fine and when tested [by means of a laboratory sieve] *for gradation as to size* shall meet the following [requirement] *requirements:*

Total passing $^1/_4$-in. screen .... *100* per cent
Total passing 10-mesh sieve [100] *not less than* *90* "

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[1] The quantity to be inserted in this blank space will be supplied by the committee when the information is available.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

[3] See p. 644.

[4] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

"(*b*) [This test] *These tests* shall be made in accordance with the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials, *with the exception that a $^1/_4$-in. screen conforming to the requirements given in the Standard Method of Mechanical Analysis of Mixtures of Sand or Other Fine Material with Broken Stone or Broken Slag, except Aggregates Used in Cement Concrete (Serial Designation: D 19) of the American Society for Testing Materials shall be used in addition to the others specified in Method D 7.*"

3. *Section 3.*—Change the side heading of Section 3 from "Mortar Strength Test" to "Mortar Strength" and change Paragraph (*a*) to read as follows by the addition of the italicized words and the omission of the words in brackets:

"(*a*) [When the sand is] *The sand shall be passed through a 10-mesh sieve and that portion retained by the 10-mesh sieve shall be discarded. The portion passing a 10-mesh sieve shall be* mixed with portland cement [passing] *conforming to* the requirements of the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials, in the proportion of 1 part cement to 3 parts of sand, by weight, according to the standard method of making 1 : 3 mortar briquettes. The resulting mortar at the age of 7 and 28 days shall have a tensile strength of at least 75 per cent of that developed in the same time by mortar of the same consistency, made of 1 part of the same cement and 3 parts of Ottawa sand."

STANDARD METHODS OF TESTING SHELLAC

(SERIAL DESIGNATION: D 29 - 17)[1]

A revision in the form of separate methods of testing entitled "Methods of Testing Shellac (D 29 - 23 T)"[2] is intended to replace the present standard methods.

STANDARD METHODS OF TESTING LUBRICANTS (SPECIFIC GRAVITY, FREE ACID, CARBON RESIDUE, VISCOSITY)

(SERIAL DESIGNATION: D 47 - 21)[3]

It is intended to withdraw Sections 6 and 7 covering the method of test for viscosity by means of the Saybolt Standard Universal Viscosimeter, this method having been combined with the method for viscosity by means of the Saybolt Furol Viscosimeter in the method entitled "Methods of Test for Viscosity of Petroleum Products and Lubricants (D 88 - 23 T)".[5]

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

[2] See p. 658.

[3] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Van H. Manning, Secretary of Committee D-2 on Petroleum Products and Lubricants, 15 W. Forty-fourth St., New York City.

[5] See p. 672.

STANDARD METHODS OF TEST FOR APPARENT SPECIFIC GRAVITY OF SAND, STONE AND SLAG SCREENINGS, AND OTHER FINE NON-BITUMINOUS MATERIALS

(SERIAL DESIGNATION: D 55 – 19)[1]

Section 4.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

"The determination shall be made with [a] *the* Jackson specific gravity apparatus (illustrated in Fig. 2) which shall consist of a burette, with graduations reading to [0.01] *0.02* in specific gravity, about [23 cm. (9 in.)] *28 cm. (11 in.)* long and with an inside diameter of about [0.6 cm. (0.25 in.)] *0.7 cm. (0.3 in.)*, which shall be connected with a glass bulb approximately 13 cm. (5¼ in.) long and 4.5 cm. (1.75 in.) in diameter, the glass bulb being of such size that from a mark on the neck [at the top to a mark on the burrette just below the bulb, the capacity is exactly 180 cc. (6.09 liquid oz.)] *above the bulb to the top graduation on the burrette, the capacity shall be such that the graduations shall read directly the specific gravity when 50 g. of material are used;* and an Erlenmeyer flask, which shall contain a hollow ground-glass stopper having [the] *a* neck of [the same bore as the burrette, and] *approximately 6 to 8 mm. bore and which* shall have a capacity of exactly 200 cc. (6.76 oz.) up to the graduation on the neck of the stopper."

STANDARD METHOD OF TEST FOR QUANTITY OF CLAY AND SILT IN GRAVEL FOR HIGHWAY CONSTRUCTION

(SERIAL DESIGNATION: D 74 – 21)[1]

A revision in the form of a separate method of test entitled "Method of Decantation Test for Sand and Other Fine Aggregates (D 136 – 22 T)"[2] is intended to replace the present standard method.

STANDARD METHOD OF TEST FOR SOLUBLE BITUMEN

(SERIAL DESIGNATION: D 4 – 11)[1]

A revision in the form of a separate tentative method of test entitled "Method of Test for the Determination of Bitumen (D 4 – 23 T)"[3] is intended to replace the present standard method.

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COAL

(SERIAL DESIGNATION: D 22 – 21)[4]

On page 764 of the 1921 Book of A.S.T.M. Standards, line 5, omit "No. 2," substituting in place thereof the word "a"; on page

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 802 (1922).

[3] See p. 751.

[4] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

766, line 4, omit "No. 2"; on page 769, beginning with the third line under Apparatus, change the following paragraph from its present form: namely,

> "*Porcelain, Silica, or Platinum Crucibles or Capsules.*—For igniting coal with the Eschka mixture.
>
> "No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.
>
> "No. 1 porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coal, owing to the deeper form, than with the shallow capsules described above.
>
> "No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the $BaSO_4$."

to read as follows:

> "*Porcelain, Silica, or Platinum Crucibles or Capsules.*—Porcelain capsules, ⅞ in. deep and 1¾ in. in diameter, or porcelain crucibles of 30 cc. capacity, high or low form, or platinum crucibles of similar size are to be used for igniting coal with the Eschka mixture.
>
> "Porcelain, platinum, alundum, or silica crucibles of 10 to 15 cc. capacity, are to be used for igniting the $BaSO_4$."

On page 770, under Method, change the second sentence in the first paragraph, on Preparation of Sample and Mixture, from its present form: namely,

> "Transfer to a No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 crucible or a platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

to read as follows:

> "Transfer to a porcelain capsule, ⅞ in. deep and 1¾ in. in diameter, or a porcelain crucible of 30 cc. capacity, high or low form, or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COKE

(SERIAL DESIGNATION: D 37 - 21)[1]

On page 790 of the 1921 Book of A.S.T.M. Standards, line 1, omit "No. 2"; on page 791, line 4, omit "No. 2"; on page 794, beginning with the third line under Apparatus, change the following paragraph from its present form: namely,

> "*Porcelain, Silica, or Platinum Crucibles or Capsules.*—For igniting coke with the Eschka mixture.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

"No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter. This capsule, because of its shallow form, presents more surface for oxidation and is more convenient to handle than the ordinary form of crucible.

"No. 1 porcelain crucibles, shallow form, and platinum crucibles of similar size may be used. Somewhat more time is required to burn out the coke owing to the deeper form, than with the shallow capsules described above.

"No. 0 or 00 porcelain crucibles, or platinum, alundum or silica crucibles of similar size are to be used for igniting the $BaSO_4$."

to read as follows:

"*Porcelain, Silica, or Platinum Crucibles or Capsules.*—Porcelain capsules, $\frac{7}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, or porcelain crucibles of 30 cc. capacity, high or low form, or platinum crucibles of similar size are to be used for igniting coke with the Eschka mixture.

"Porcelain, platinum, alundum, or silica crucibles of 10 to 15 cc. capacity, are to be used for igniting the $BaSO_4$."

On page 795, under Method, change the first paragraph on Preparation of Sample and Mixture from its present form: namely,

"*Preparation of Sample and Mixture.*—Thoroughly mix on glazed paper, 1 g. of 60-mesh coke and 3 g. of Eschka mixture. Transfer to a No. 1 porcelain capsule, 1 in. deep and 2 in. in diameter, or a No. 1 porcelain crucible or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

to read as follows:

"*Preparation of Sample and Mixture.*—Thoroughly mix on glazed paper, 1 g. of 60-mesh coke and 3 g. of Eschka mixture. Transfer to a porcelain capsule, $\frac{7}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, or a porcelain crucible of 30 cc. capacity high or low form, or platinum crucible of similar size, and cover with about 1 g. of Eschka mixture."

STANDARD METHODS OF SAMPLING AND ANALYSIS OF CREOSOTE OIL

(SERIAL DESIGNATION: D 38 – 18)[1]

Sections 17 and 18.—It is recommended that Sections 17 and 18, comprising a description of a float test of residue, be withdrawn.

A revision in the form of a separate tentative method of test entitled "Method of Test for Coke Residue of Creosote Oil (D 168 – 23 T)"[2] is intended to replace Sections 19 and 20 of the present standard methods.

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, Forest Products Laboratory, Madison, Wis.

[2] See p. 771.

STANDARD METHODS OF TESTING COTTON RUBBER-LINED HOSE

(SERIAL DESIGNATION: D 15 - 15)[1]

A revision in the form of separate methods of testing entitled "Methods of Testing Rubber Products (D 15 - 23 T)"[2] is intended to replace the present standard methods.

STANDARD GENERAL METHODS OF TESTING COTTON FABRICS

(SERIAL DESIGNATION: D 39 - 20)[3]

Title.—Change the title to read as follows by the omission of the word in brackets:

"Standard [General] Methods of Testing Cotton Fabrics."

Section 1.—Add a central heading immediately preceding this section to read as follows:

"General Test Methods."

Fig. 2.—Change Fig. 2, illustrating the "grab test," so as to show the strip 6 by 4 in. in size, and showing the jaws 3 in. apart.

Table I.—Change the dimensions of specimen for the grab test given in Column 2 of the table from 5 by 2 in. to 6 by 4 in.; change the distance between jaws for the grab method from 1 in. to 3 in.

Change the Diagram No. 2 so as to show a width of fabric of 22 in. instead of 12 in. and showing specimens 6 by 4 in. in size instead of 5 by 2 in.

Table II.—Add a reference under the column headed "Humidity Conditions" opposite "ducks, including hose duck, belt duck, tent duck, army duck, enameling duck, sail duck, numbered duck," to read "See Section 16."

The present notes (*a*) and (*b*) in the column headed "Humidity Conditions" are to apply only to Drill, Sheeting, Osnaburg, Coutils, and Balloon Cloth.

Add a new section to read as follows:

"*Method of Determining Crimp in Tire Fabric.*—Threads for crimp test of tire fabric shall be taken from the inside edge of test piece as near the center line of the roll as possible. Threads for crimp test shall be laid out by marking across them in the fabric parallel lines not less than 6 in. apart. An even number of threads not less than four in number shall be taken for each warp and each filling test. These threads shall be ravelled from the fabric after marking, allowing about 2 in. extra on each end of the threads beyond the marks. The threads shall then be straightened by a machine which applies a constant load of 75 g. and the length between the original markings shall then be read in terms of the yarn length as it lay in the fabric. The machine shall be equipped with a dial or scale so arranged as to read the percentage crimp directly."

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[1] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. C. B. Martin, Secretary of Committee D-11 on Rubber Products, Room 850, 466 Lexington Ave., New York City.

[2] See p. 870.

[3] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. T. Fisher, Secretary of Committee D-13 on Textile Materials, National Association of Cotton Manufacturers, 45 Milk St., Boston, Mass.

Add six new sections to read as follows under the new central heading "Specific Test Methods":

TEST METHODS FOR DUCKS, INCLUDING HOSE, BELT, TENT, ARMY, ENAMELING, SAIL AND NUMBERED DUCKS

"14. All test procedure not covered in these specific methods, shall be in accordance with the foregoing General Methods of Testing Cotton Fabrics.

"15. *Sampling.*—From each delivery of 1000 yd. or fraction thereof, samples of not more than 2 linear yd. each shall be cut from any part of at least 2 rolls for test purposes.

"16. *Humidity Conditions.*—Tests may be made under prevailing atmospheric conditions, except in the settlement of disputes concerning weight and strength. In such case, tests shall be made upon material having normal moisture content obtained by exposure for at least 4 hours to an atmosphere of 65-per-cent relative humidity at a temperature of 70° F.

"17. *Weight.*—In case any dispute arises in regard to weight, the weight per square yard shall be determined from the actual average width, the invoiced yardage (verified when necessary), and the actual weight of the entire bolt or roll. The results of tests on one or two yards for width and weight shall not be used alone as a basis for rejection.

"18. *Threads per Inch.*—(*a*) The count shall be determined by ascertaining the number of threads in 3 in., taken consecutively and reducing to the number of threads per inch.

"(*b*) The warp count shall be determined at five different places not less than 8 in. from either selvage for materials 26 in. or over in width; for materials under 26 in. in width, it shall not be taken nearer the selvage than one-fourth of the entire width of the fabric.

"(*c*) The filling count shall be determined at five places about equi-distant throughout the roll, midway between the selvages and not within ten yards of either end.

"19. *Strength.*—(*a*) The tensile strength shall be determined on an approved type of inclination balance breaking machine. The maximum capacity of the machine shall be 800 lb.

"(*b*) The 1 by 1 by 3-in. grab method of testing shall be used, defined as follows:

"The lower half of each pair of jaws shall be 2 in. or more in width, and the upper half shall be 1 in. in width. (The jaws shall be planed smooth and flat, with edges slightly rounded to prevent cutting.) The initial length of the test pieces between the jaws of the testing machine shall be 3 in., and the pulling jaw shall travel at a uniform rate of 12 in. per minute. Ten test pieces, 6 in. in length by 4 in. in width, shall be cut, five in the direction of the warp and five in the direction of the filling, respectively. Care shall be taken that no two test pieces include the same threads. The average result of the tests shall be recorded separately for warp and filling. No sample for testing shall be taken at less than 8 in. from either selvage for materials 26 in. or over in width, or for materials under 26 in. at less than one-fourth of the entire width of the fabric. If the width of the materials does not admit of cutting pieces as stated above, they shall be taken as near the center as possible.

"In the case of a break evidently below the general average for the fabric, a second test on the same threads shall be made and this test shall then be used in obtaining the average result."

STANDARD DEFINITIONS OF TERMS RELATING TO PAINT SPECIFICATIONS

(SERIAL DESIGNATION: D 16 - 22)[1]

Add the following two new definitions of terms:

Toughness.—Relative degree of resistance to impact without fracture; apposed to brittleness.

Elasticity of Paint and Varnish Films.—That property which allows a paint or varnish film to follow, without rupture, changes in the extent and form of the surface to which it is applied.

E. MISCELLANEOUS SUBJECTS

STANDARD METHODS OF MECHANICAL TESTING OF METALLIC MATERIALS

(SERIAL DESIGNATION: E 1 - 18)[2]

Revisions in the form of separate tentative methods entitled "Methods of Verification of Testing Machines (E 4 - 23 T)"[3] and of separate tentative definitions of terms entitled "Definitions of Terms Relating to Methods of Testing (E 6 - 23 T)"[4] are intended to replace portions of the present standard methods.

STANDARD DEFINITIONS AND RULES GOVERNING THE PREPARATION OF MICROGRAPHS OF METALS AND ALLOYS

(SERIAL DESIGNATION: E 2 - 20)[5]

A revision in the form of additional definitions of terms entitled "Tentative Definitions of Terms Relating to Metallography (E 2 - 23 T)"[6] is intended to become a part of the present standard definitions.

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[1] A.S.T.M. Standards Adopted in 1922. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

[2] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. H. F. Moore, Chairman of Sub-Committee, of Committee E-1, on Mechanical Testing of Materials, University of Illinois, Urbana, Ill.

[3] See p. 911.

[4] See p. 937.

[5] 1921 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallograpy, Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.

[6] See p. 943.

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